RBR

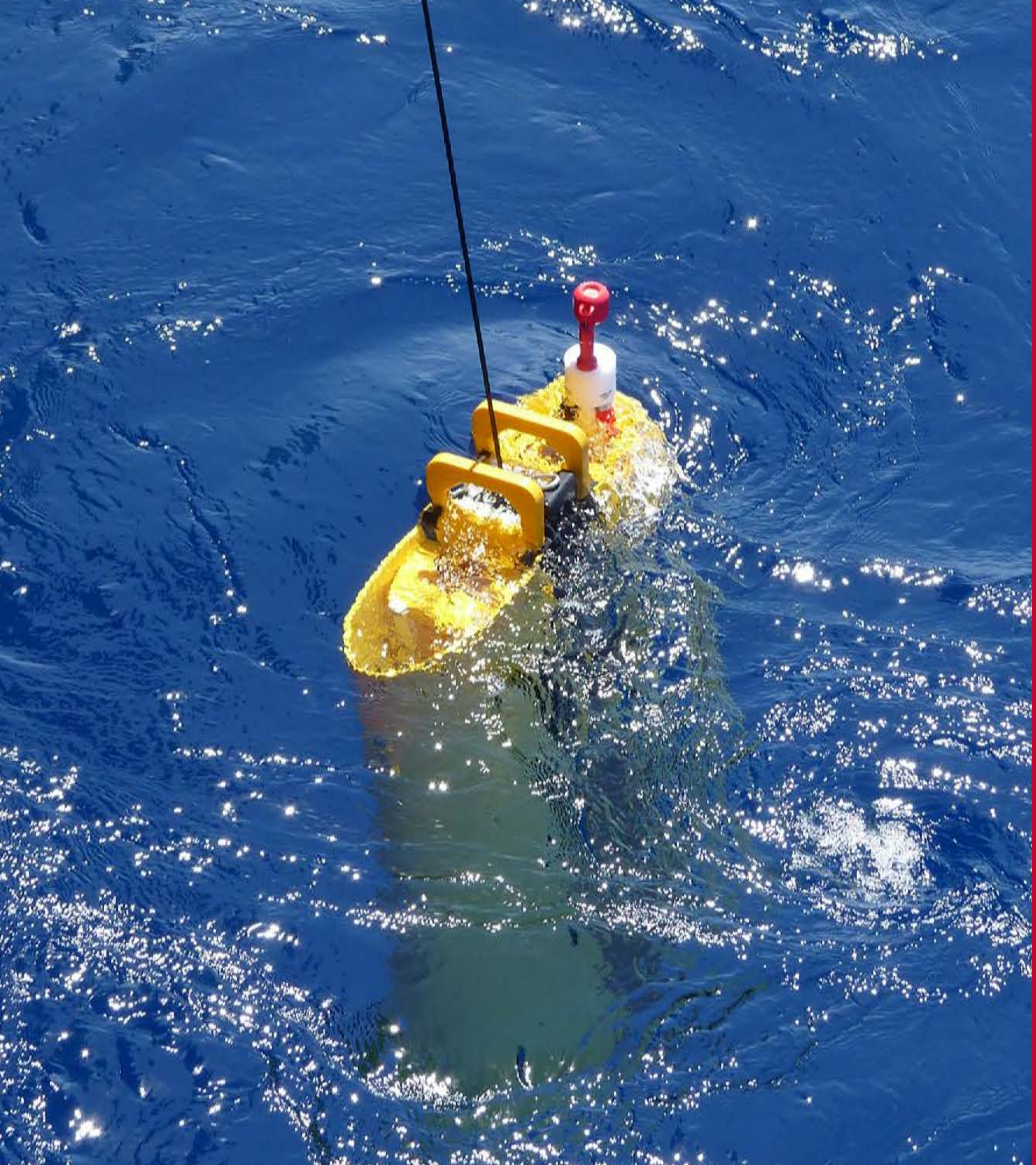
Welcome, the RBR Webinar will begin shortly…

DEL MAR OCEANOGRAPHIC

RBR
rbr-global.com

Multi-parameter observations and telemetry with the DMO Wirewalker

Greg Johnson, Chris Kontoes, Drew Lucas



Outline

Motivation

Sensor system – RBRconcerto CTD++

Mechanical system – DMO WW

Data & Telemetry system – RBRcervello, datahosting

Science

DEL MAR OCEANOGRAPHIC

Product Family

Compact instrument

- RBRsolo T/D/DO/PAR
- RBRduet T.D
- tide and wave variants
- 25M readings on any AA battery

Standard instrument

- RBRconcerto (3-5 channels)
- RBRmaestro (6-10 channels)

One app to rule them all: Ruskin

RBR

RBR*concerto* CTD

twist activation

direction dependent sampling

Any AA

USB-C

RBR concerto CTD++

Dissolved oxygen

Backscatter / turbidity

Chlorophyll

pH

PAR

narrow band (ir)radiance

RBR

RBR*fermata*

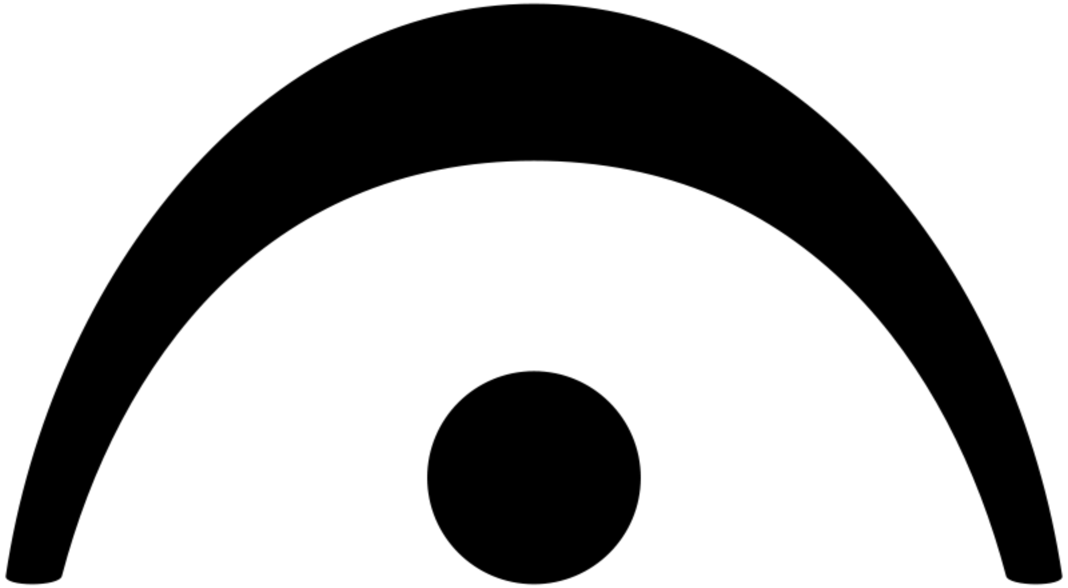
“to prolong beyond the normal duration”

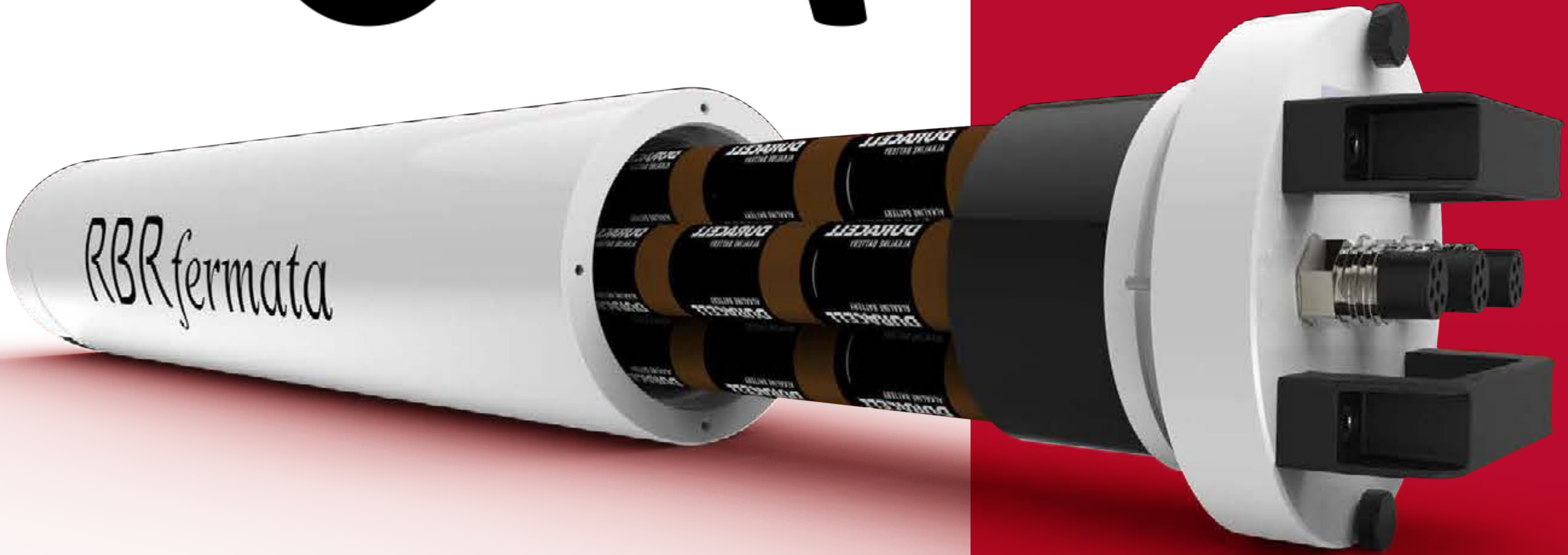
56 D-cell pack

1kWh alkaline

3kwH lithium

drawings included for your own pack construction

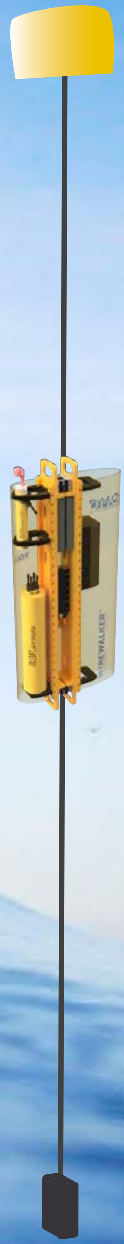




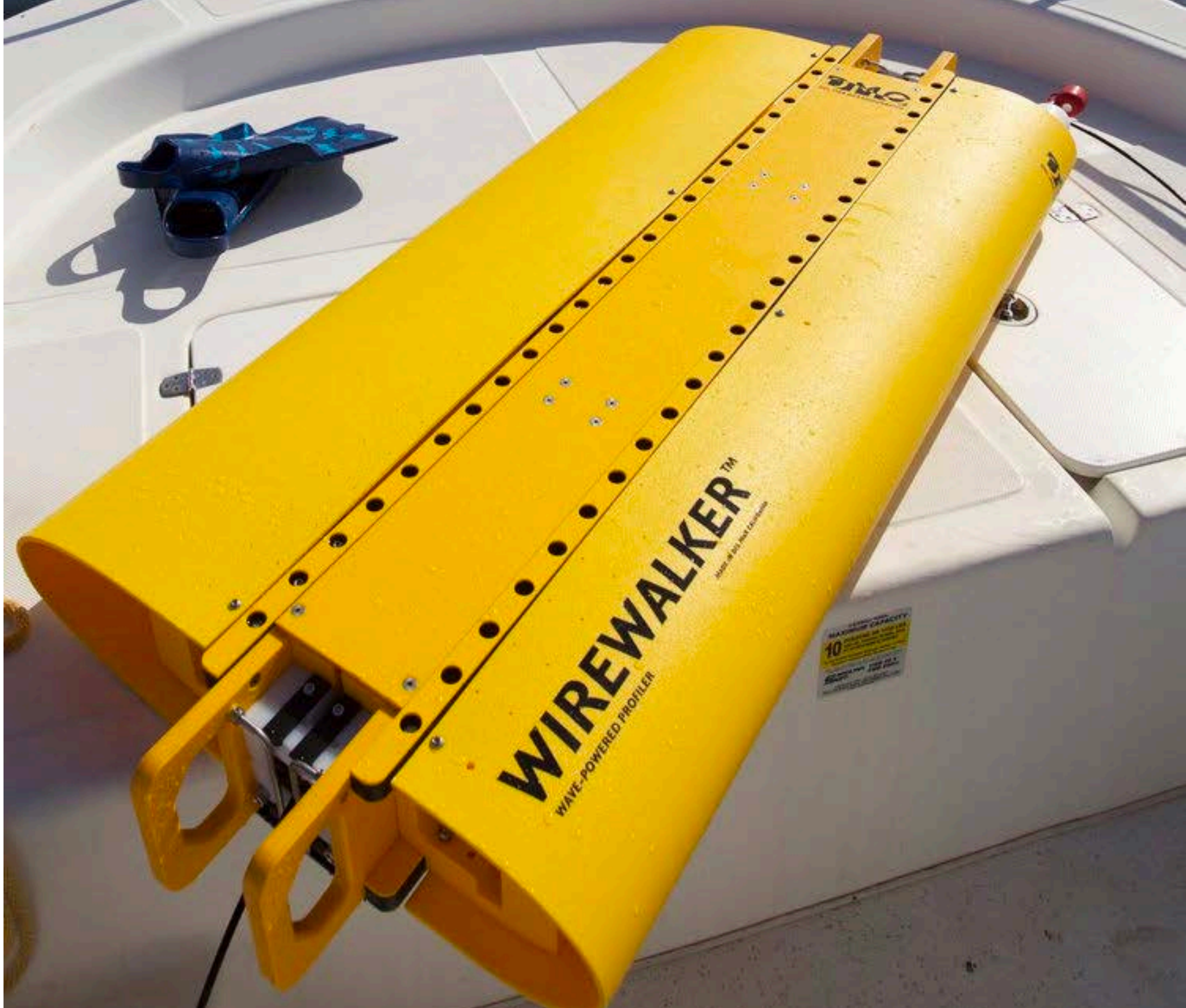
RBR

THE WIREWALKER

AN INTRODUCTION TO WAVE POWERED PROFILING

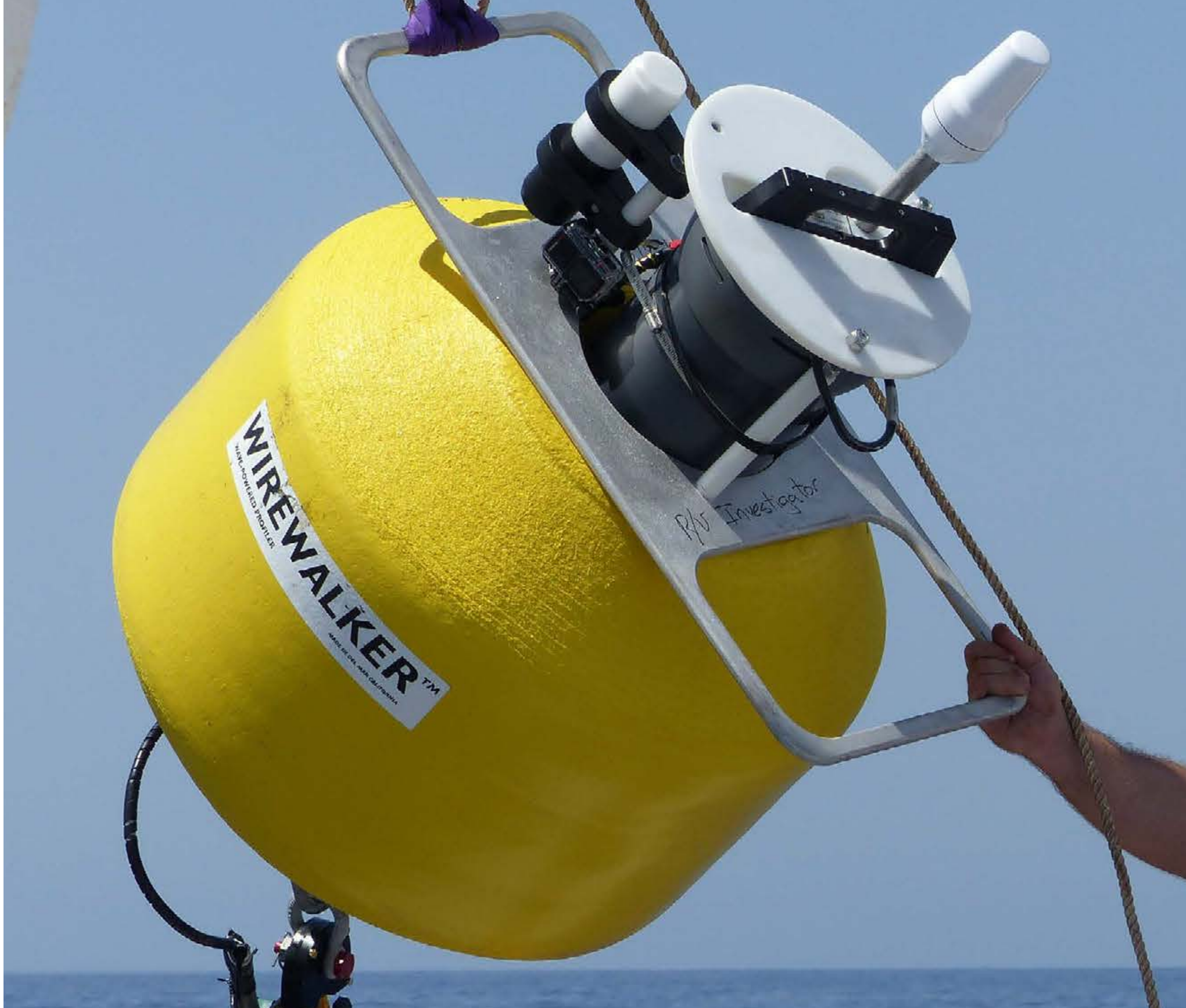


DEL MAR OCEANOGRAPHIC



SURFACE BUOY

36” (0.9m) Diameter
600lb (275kg) of Buoyancy
10” (0.25m) Dia. Well
GPS Beacon
Flasher



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JACKETED WIRE ROPE

3/16" (5mm) Diameter
Wire Terminations
- Standard or Hammerhead

Turnaround Stopper
- Assemblies

DMO
DEL MAR OCEANOGRAPHIC

SUSPENDED WEIGHTS

2 x 45lb (20kg) weights

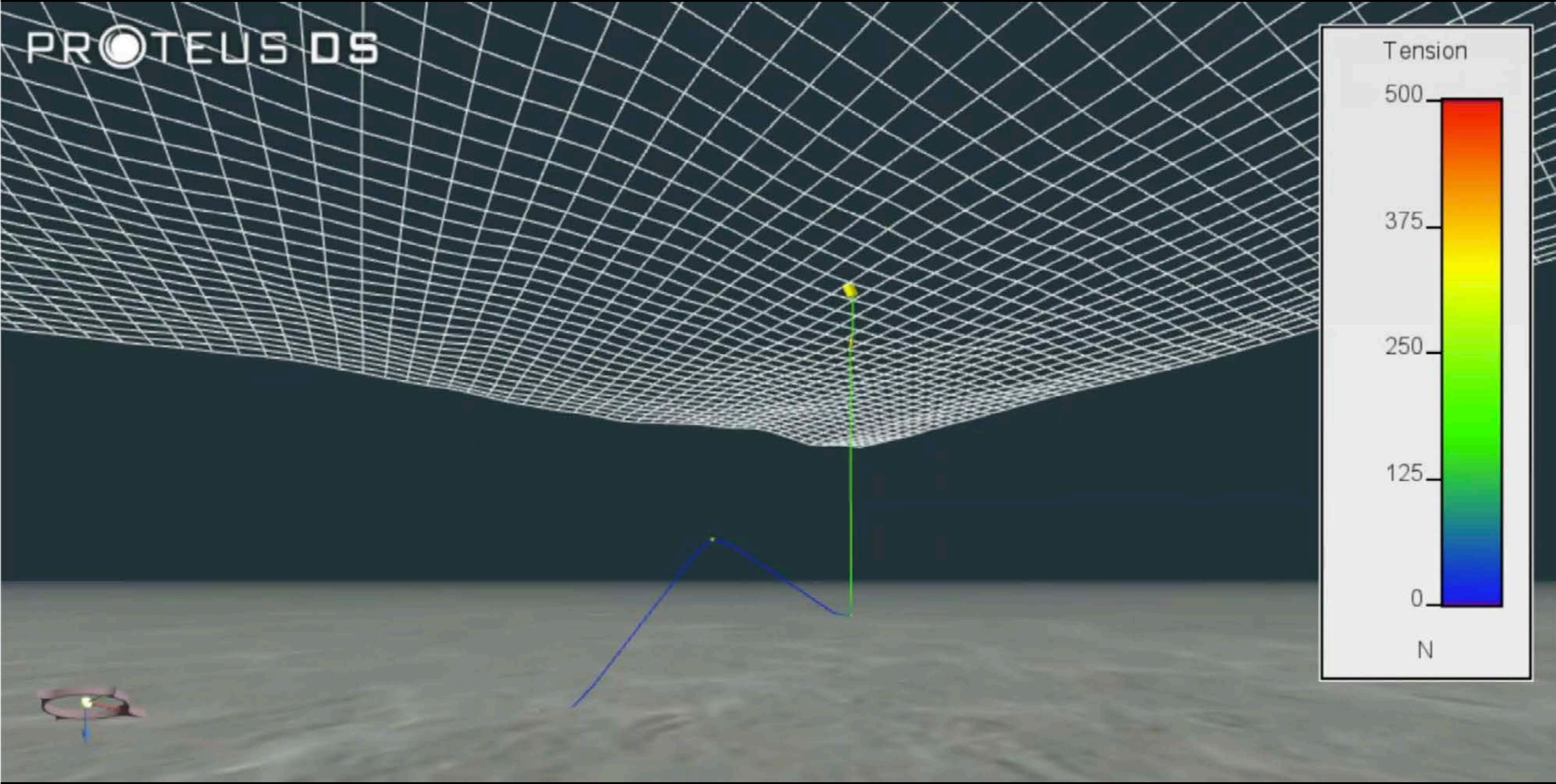
DEL MAR OCEANOGRAPHIC

Photo: Karin Björkman, UH Manoa

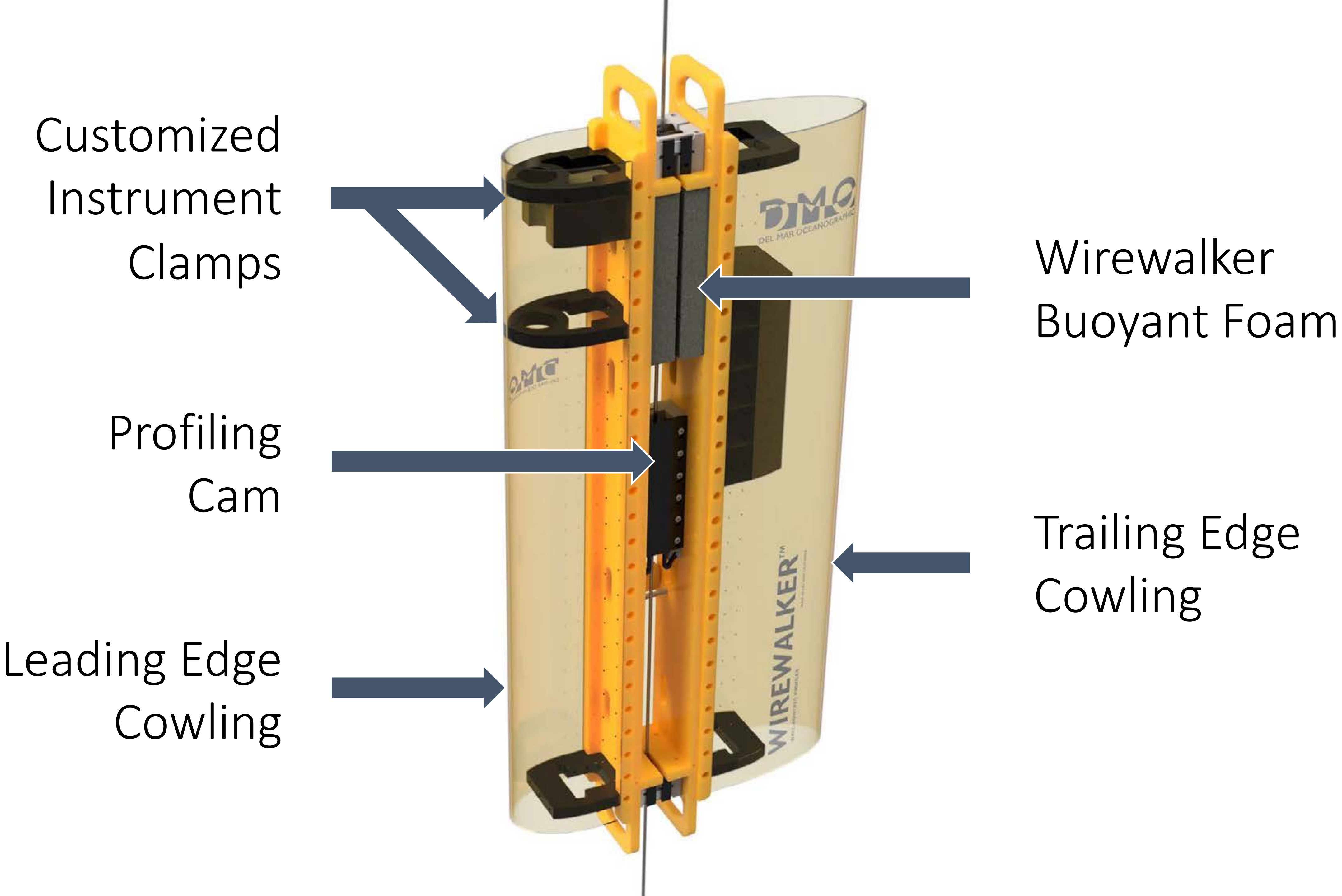
WIREWALKER PROFILER

Dims: 62” x 24” x 6.5”
Rapid Profiling
Zero Power
Decoupled on Ascent
Free-Drift or Moored
Protective Cowlings

DEL MAR OCEANOGRAPHIC


PROTEUS DS
Tension
500
375
250
125
0
N

Wirewalker Animation | By Melissa Omand and Colleen Durkin



Customized Instrument Clamps
Wirewalker Buoyant Foam
Profiling Cam
Trailing Edge Cowling
Leading Edge Cowling
DMO
DEL MAR OCEANOGRAPHIC
WIREWALKER™

Wirewalker
Buoyancy

RBRfermata
(Batteries)

CTD
*Facing Up

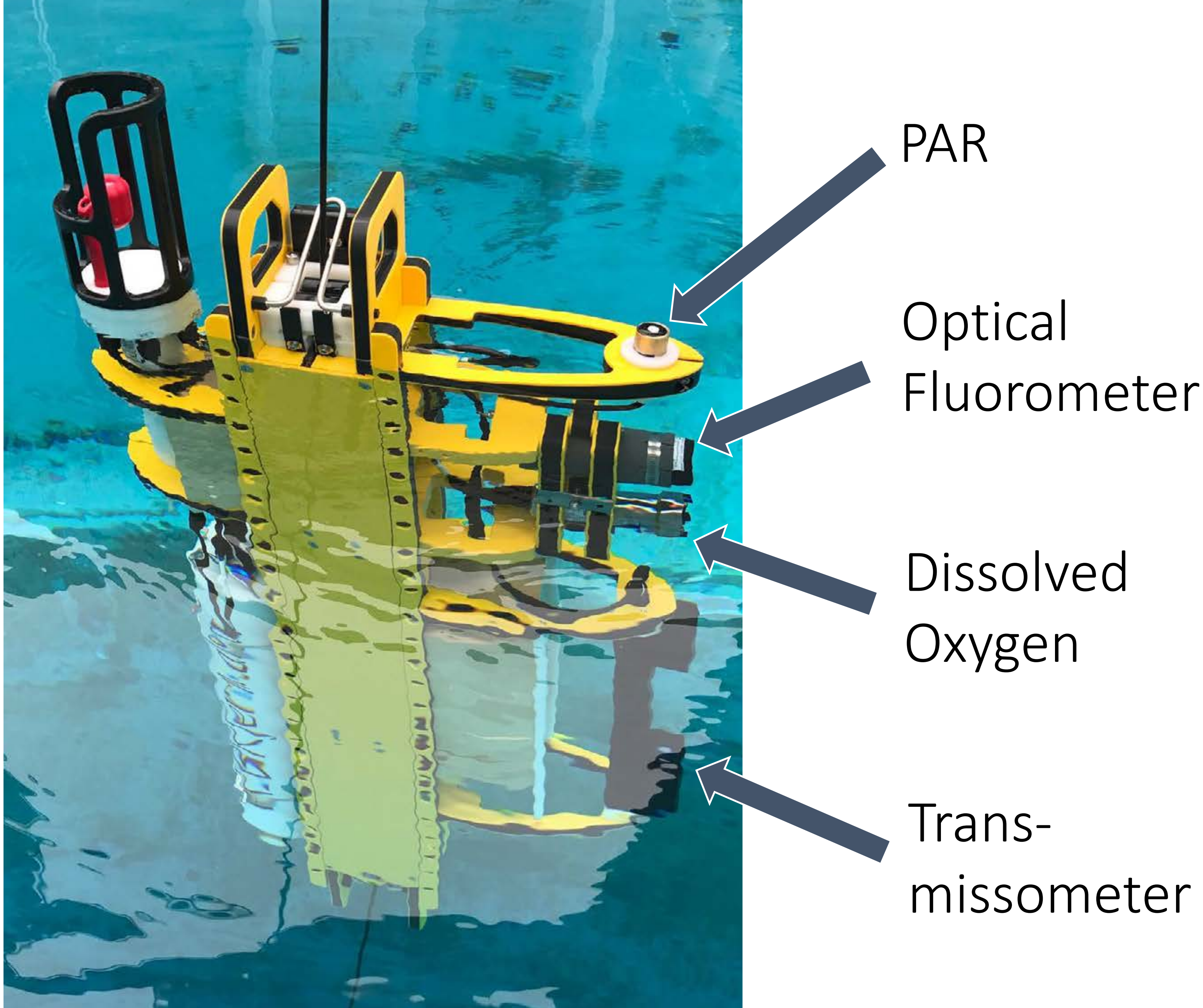
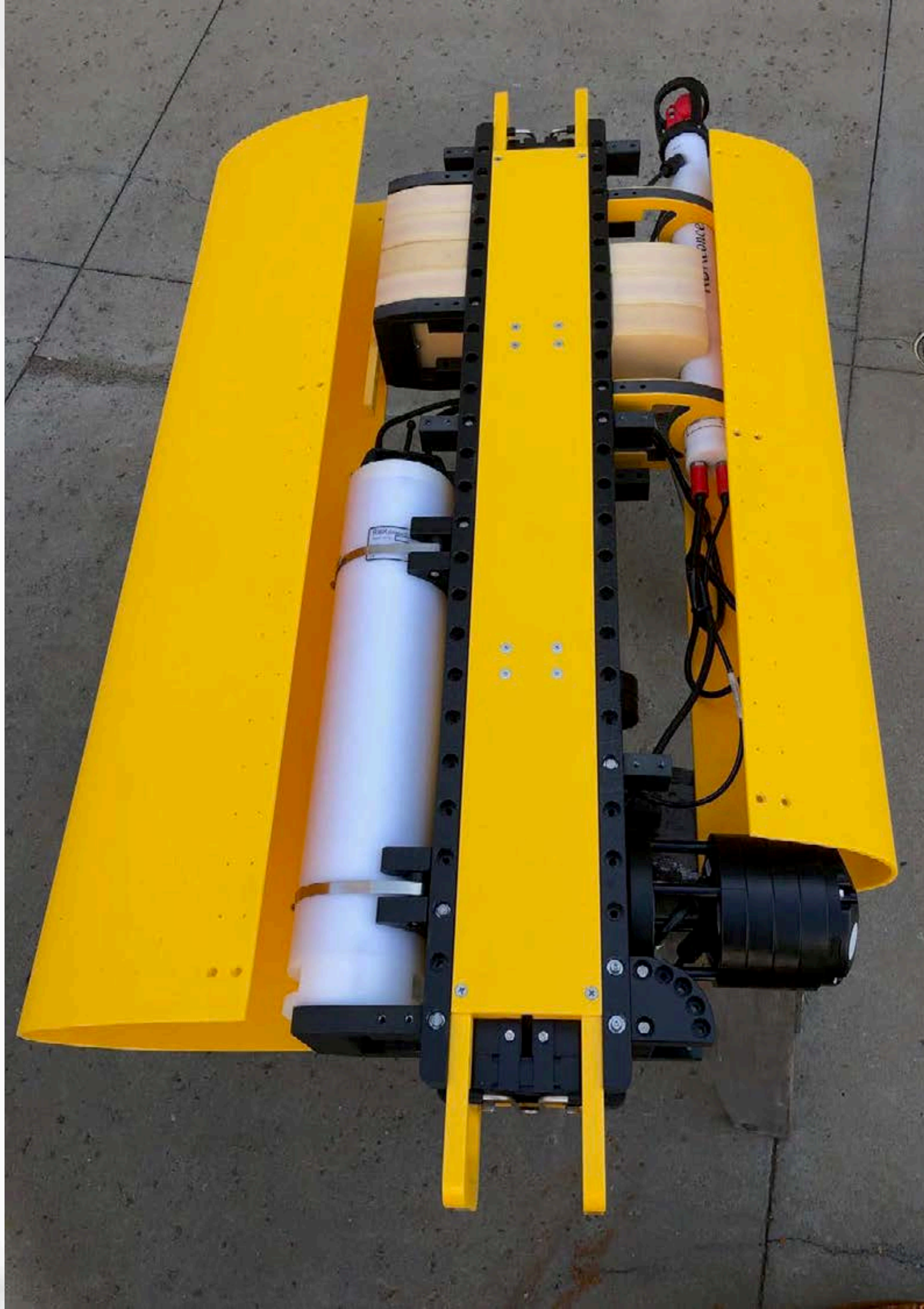

PAR
Optical Fluorometer
Dissolved Oxygen
Trans-missometer

Photo: Karin Björkman, UH Manoa


Little
Dragon


WIREWALKER™



WIREWALKER SUMMARY

Zero Power
Rapid Profiles
Decoupled on Ascent
Flexible Payload
Numerous Scientific Applications

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APPLICATIONS

- Biophysical Interactions
- Biogeochemistry
- Ocean mixing
- Microstructure
- Internal Waves
- Harmful Algal Blooms
- Oil Response & Science
- Plume Monitoring
- Aquaculture
- Tactical Oceanography
- Limnology

Surfacing the data

Inductive modem to get the data from WW to buoy

4800 baud

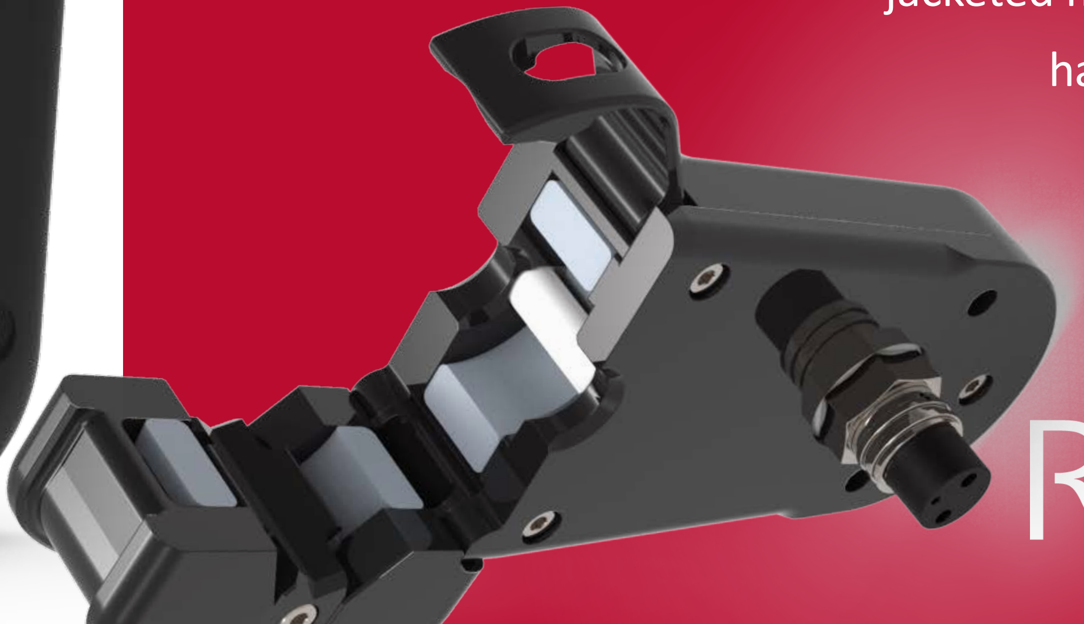
transparent modem

robust to intermittent drop outs (damaged cable)

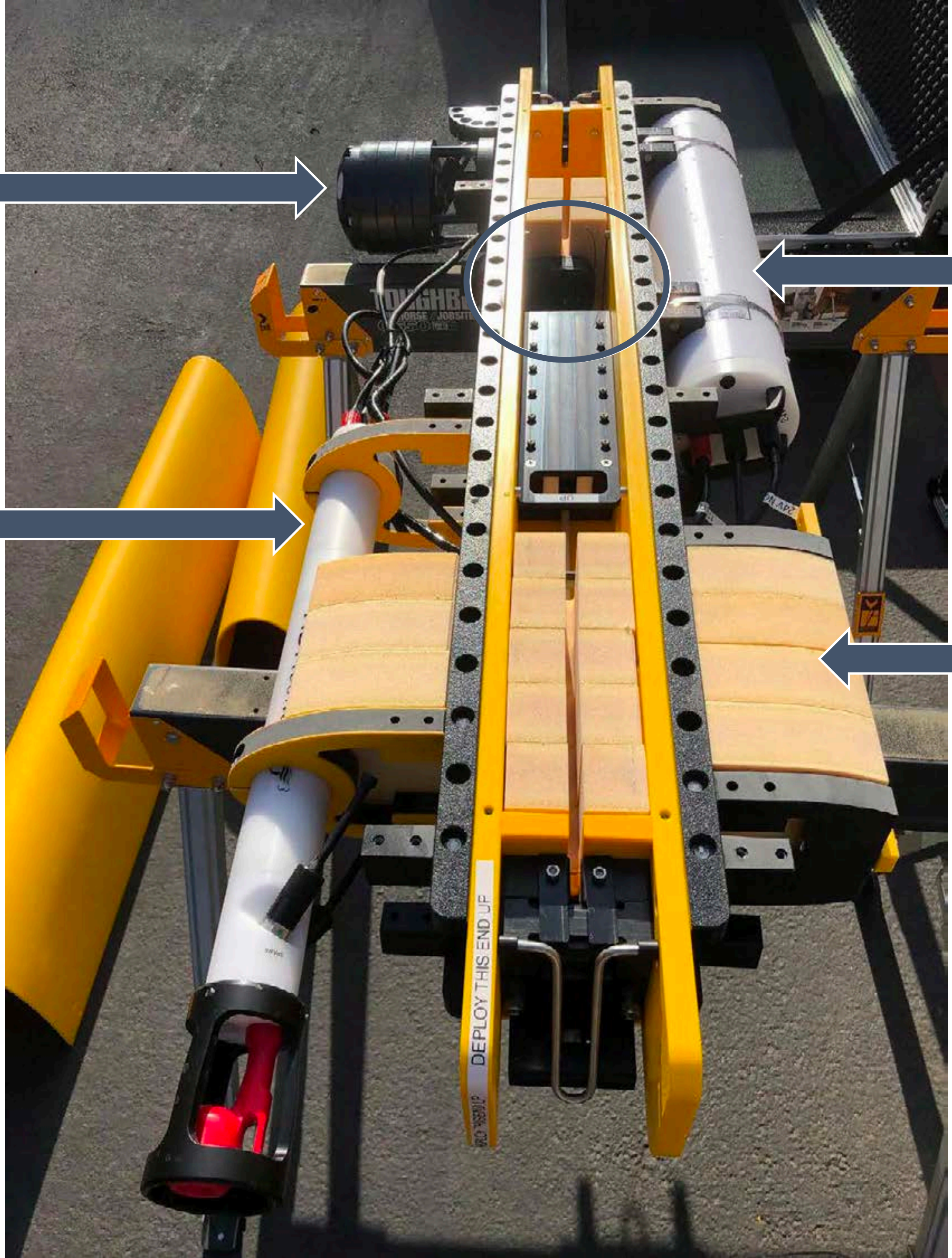
fast enough to get 8Hz five channel data up

jacketed mooring line

hammerhead



RBR


ADCP
RBRfermata
(Batteries)
RBRssm
attached to
RBRconcerto
Wirewalker
Buoyancy
DEPLOY THIS END UP

RBR ssm

Buoy induction

Topside

RBR*cervello* – the brains of the operations

Hands off operation – power and go

Internal storage

USB stick transfer for download

USB stick transfer for deployment changes

GSM when in range

Iridium when not

Debug port

Inductive test loop included

Autonomy Engine

Predict your deployment length

Online access from anywhere

RBR*cervello* Deployment Calculator

Parameters you'll likely want to change are shown in **bold**. Calculated/output values are shown in *italics*. Constant/measured values unlikely to change are shown in grey.

Instrument

Instrument deployment lifetime is calculated separately in Ruskin. However, in order to calculate the modem duty cycle (a prerequisite for estimating its power consumption), we must know some basic information about the instrument to know how much data it will produce.

Sample rate: 8 **Hz**

Number of channels: 3

Direction-dependent sample reduction: 50 %

Efficacy of direction-dependent sampling depends on configuration and deployment conditions. See the Logger3 command reference for details.

Data rate: 80 *bytes/second*

Mooring Line Modem

Whether a HEM is included in the system, and its means of attachment to the inductive loop, have a significant impact

GPS

Interval: 600 **seconds**

Activity duration: 60 s; power consumption: 0.45 W

Average power consumption: 0.04 *W*

Telemetry

Interval: 1800 **seconds**

Telemetry compression reduction: 80 %

The default reduction value – 80% – is based on empirical data collected across multiple deployments. It encompasses the effects of not only compression, but also real-world telemetry overhead from the messaging protocol (connection metadata, diagnostic data, message delimiters) and any repeated data transmitted due to telemetry drops/outages. Strictly speaking, the actual compression (quantization + differential encoding) is significantly more effective, but to show only the compression ratio would be a misrepresentation of the true amount of data transferred.

For GSM, use "-5%": no compression is used, but there is still protocol overhead which increases the payload size.

Data rate: 28800 *bytes/telemetry session*

Modem: Iridium RUDICS

Single-board Computer

Average power consumption: 0.69 *W*

Overall

Battery capacity: 1080 **Wh**

- RBR#0007569: 1080 Wh
- RBR#0002854: 360 Wh

Deployment life: 39.21 *days*

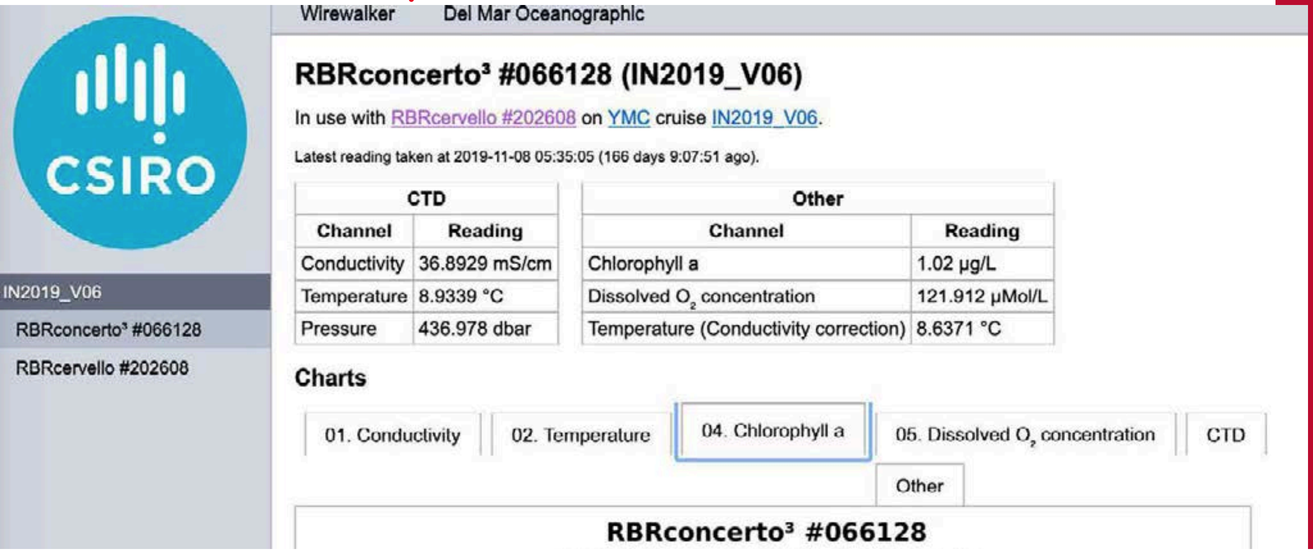
Average power consumption: 1.15 *W*

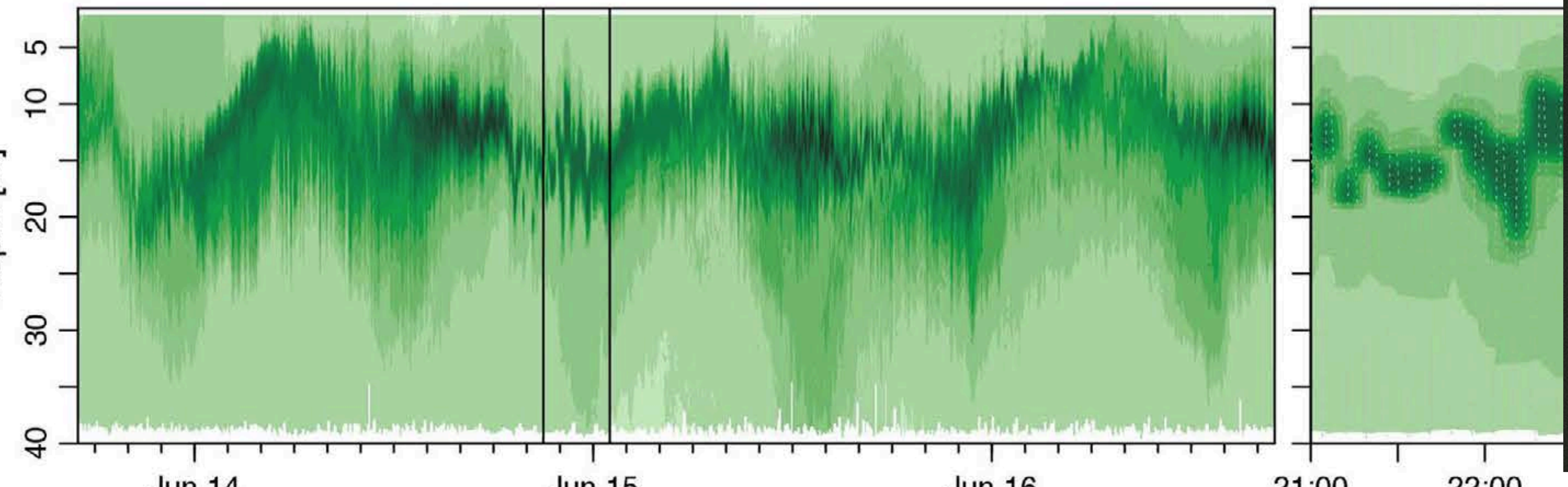
- Getting started
  - Required tools
  - Airtime
  - Configuration
  - Bench testing
  - Deployment calculator
- Features
  - Deployment management
  - **USB interface**
    - Retrieving data
    - Applying firmware updates
  - Data Hosting
- Troubleshooting
  - Debug port
  - MLM troubleshooting
  - Telemetry troubleshooting
    - GSM

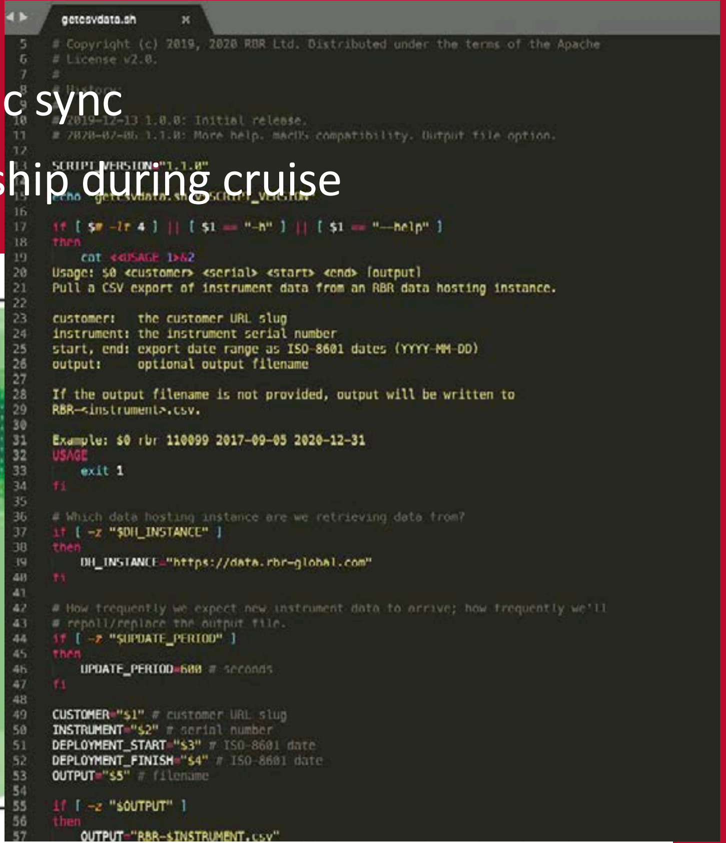
```
curl --location --remote-name --remote-header-name --compressed
'http://data.rbr-global.com/rbr/download/080296?from=2016-09-
08&to=2016-09-09'
```

Data at home

- RBR data hosting service
- GSM or Iridium feeds
- Cloud hosting (both in North America and China)
- Simple daily charts
- API to pull data
- curl example
- shell scripts for periodic sync
- easy to get all data to ship during cruise







Drew Lucas, Scripps

The Dynamics are in the Details: a decade of ocean exploration with the Wirewalker Profiler

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Drew Lucas, Ph.D.[1,2]

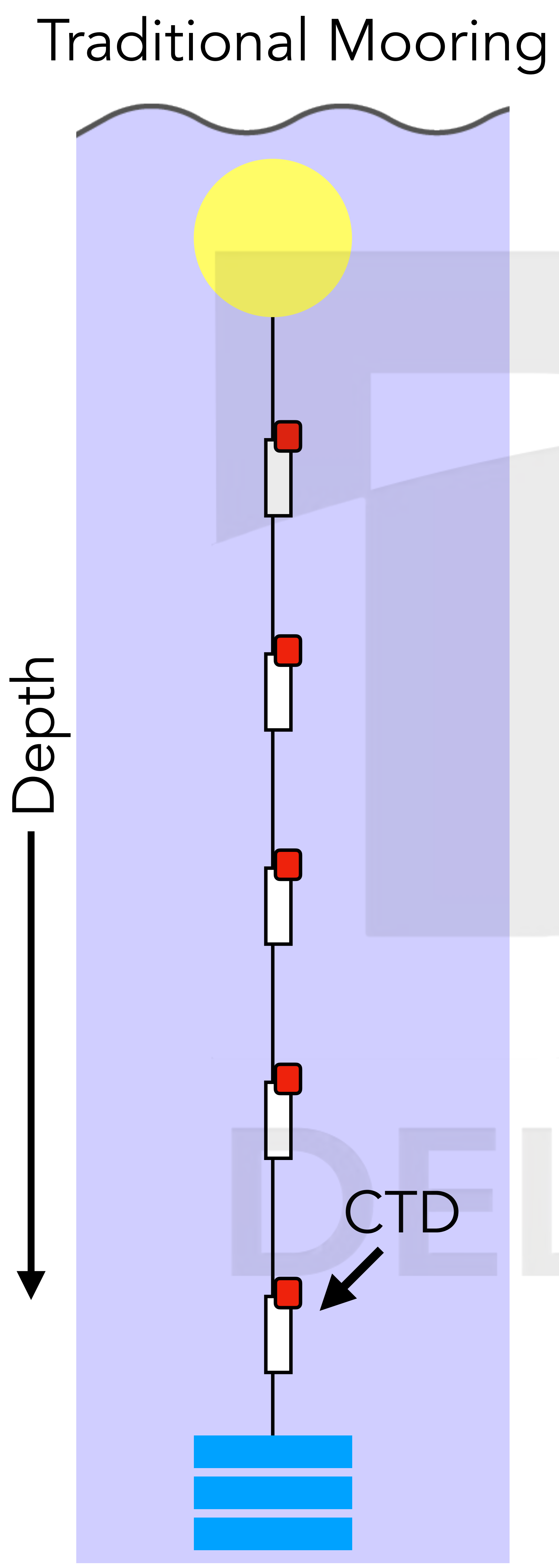
Assistant Professor

[1]Marine Physical Laboratory, Scripps Institution of Oceanography
and [2]Department of Mechanical and Aerospace Engineering
University of California, San Diego, CA USA

UC San Diego
JACOBS SCHOOL OF ENGINEERING
Mechanical and Aerospace Engineering

co-founder and principal:
DMO
DEL MAR OCEANOGRAPHIC

Why the Wirewalker?



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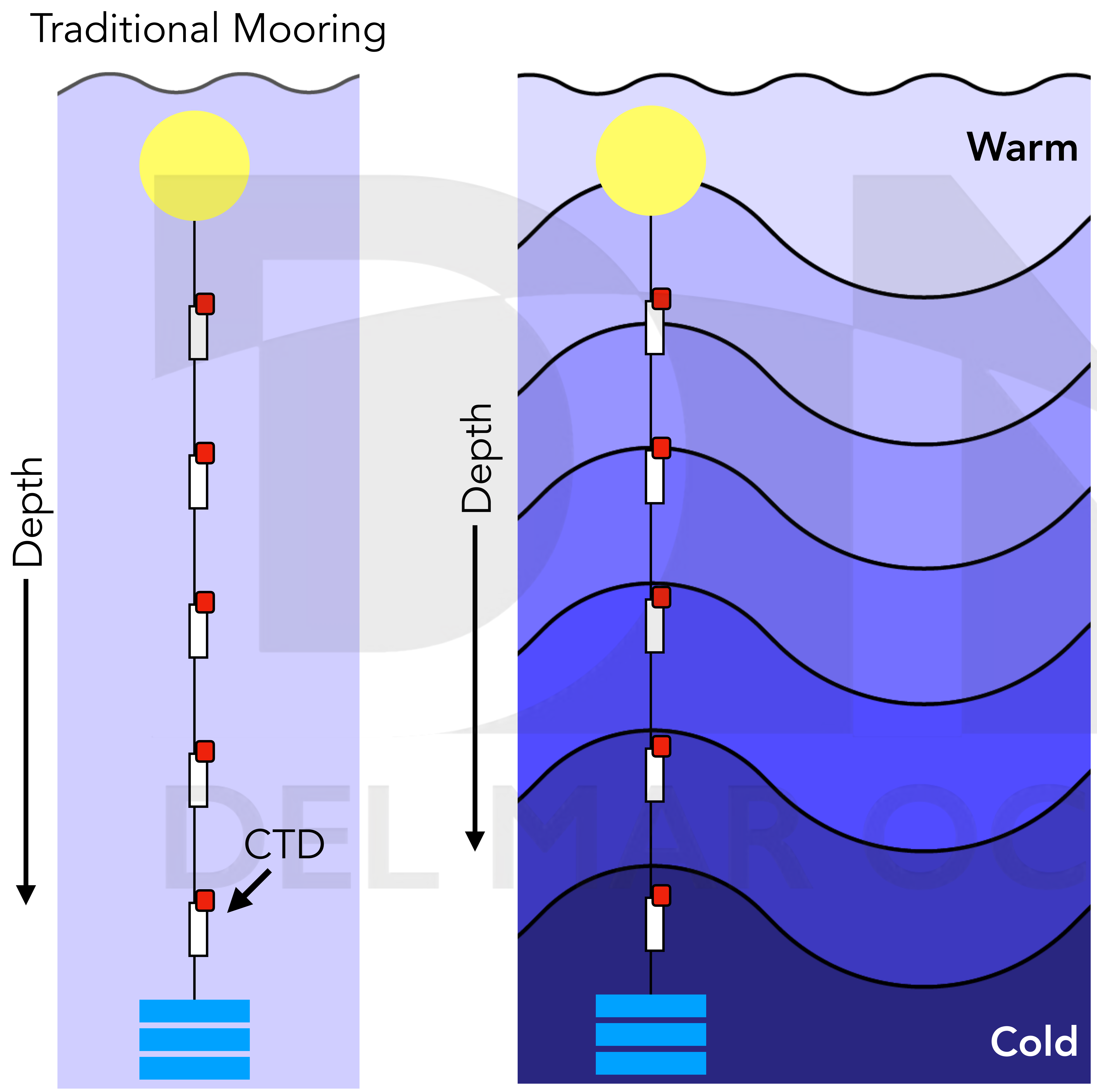

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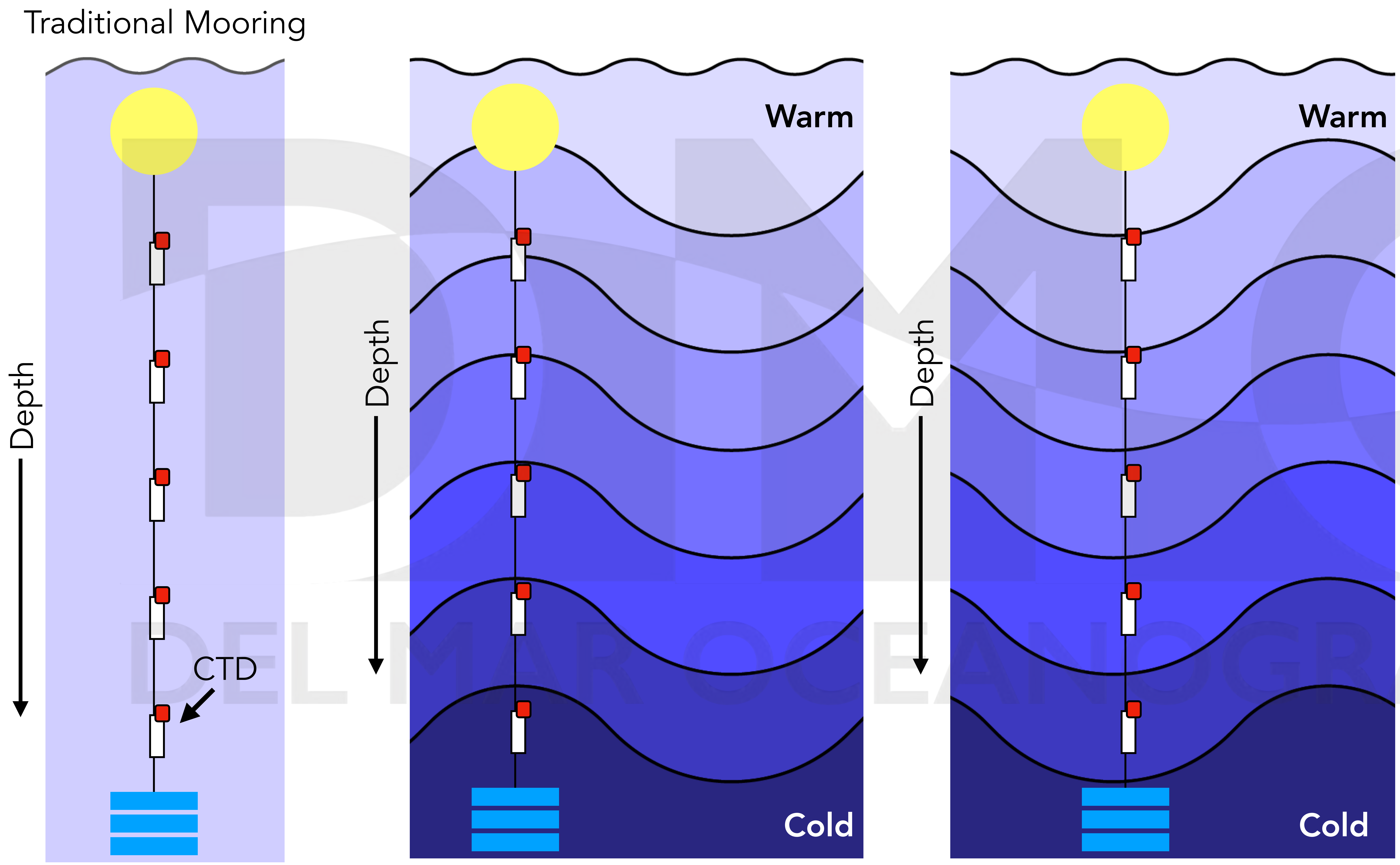

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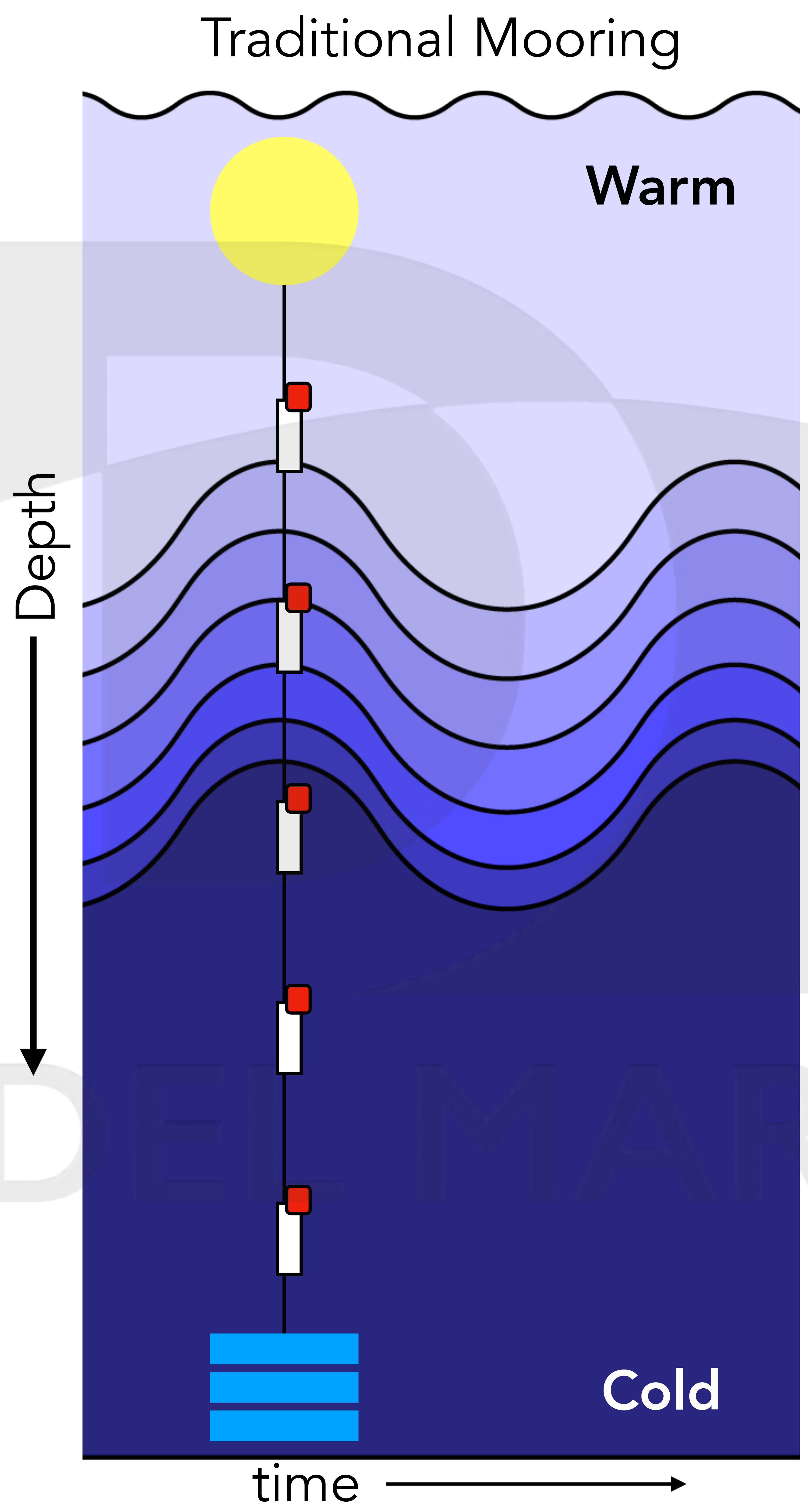

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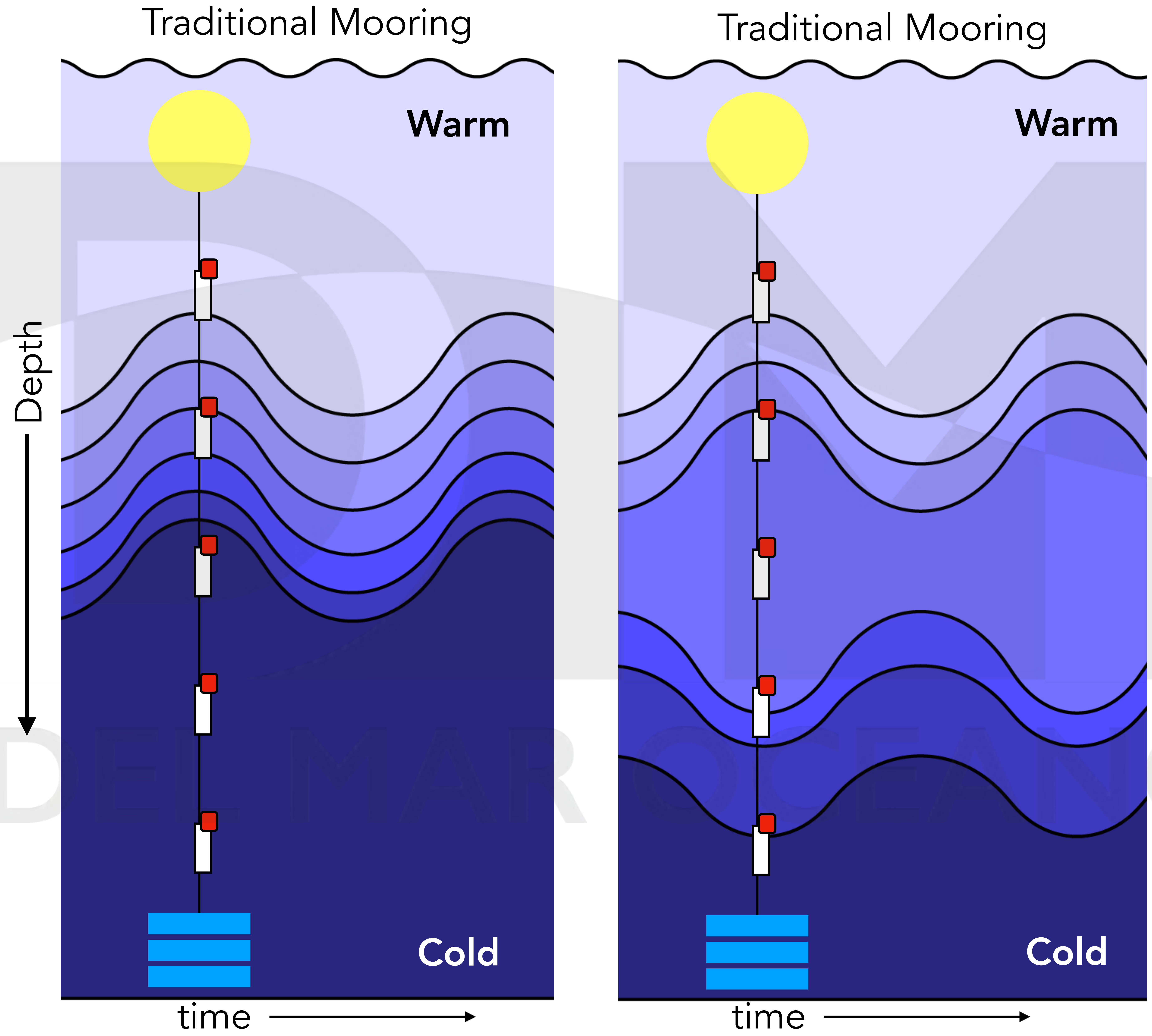

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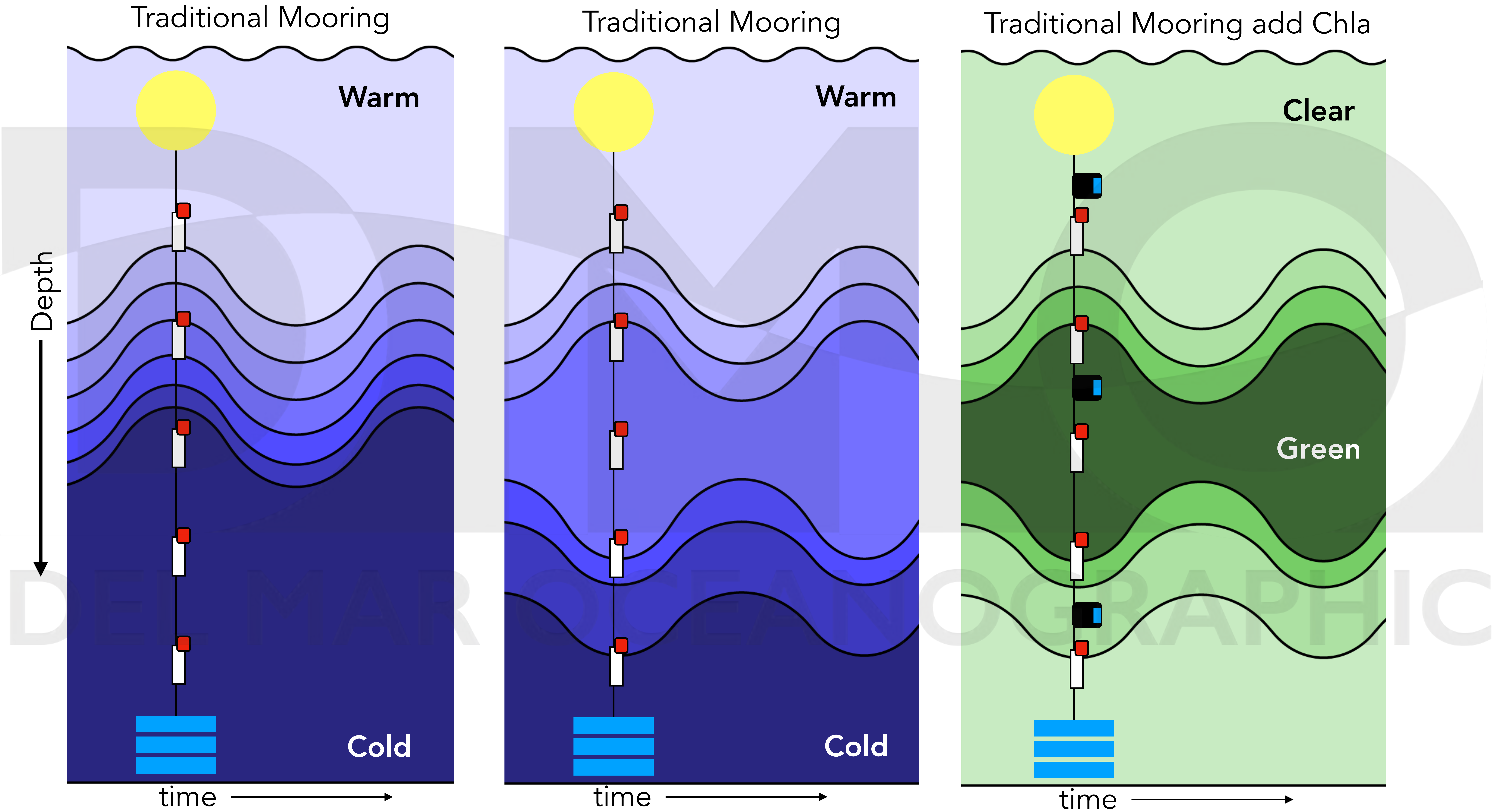

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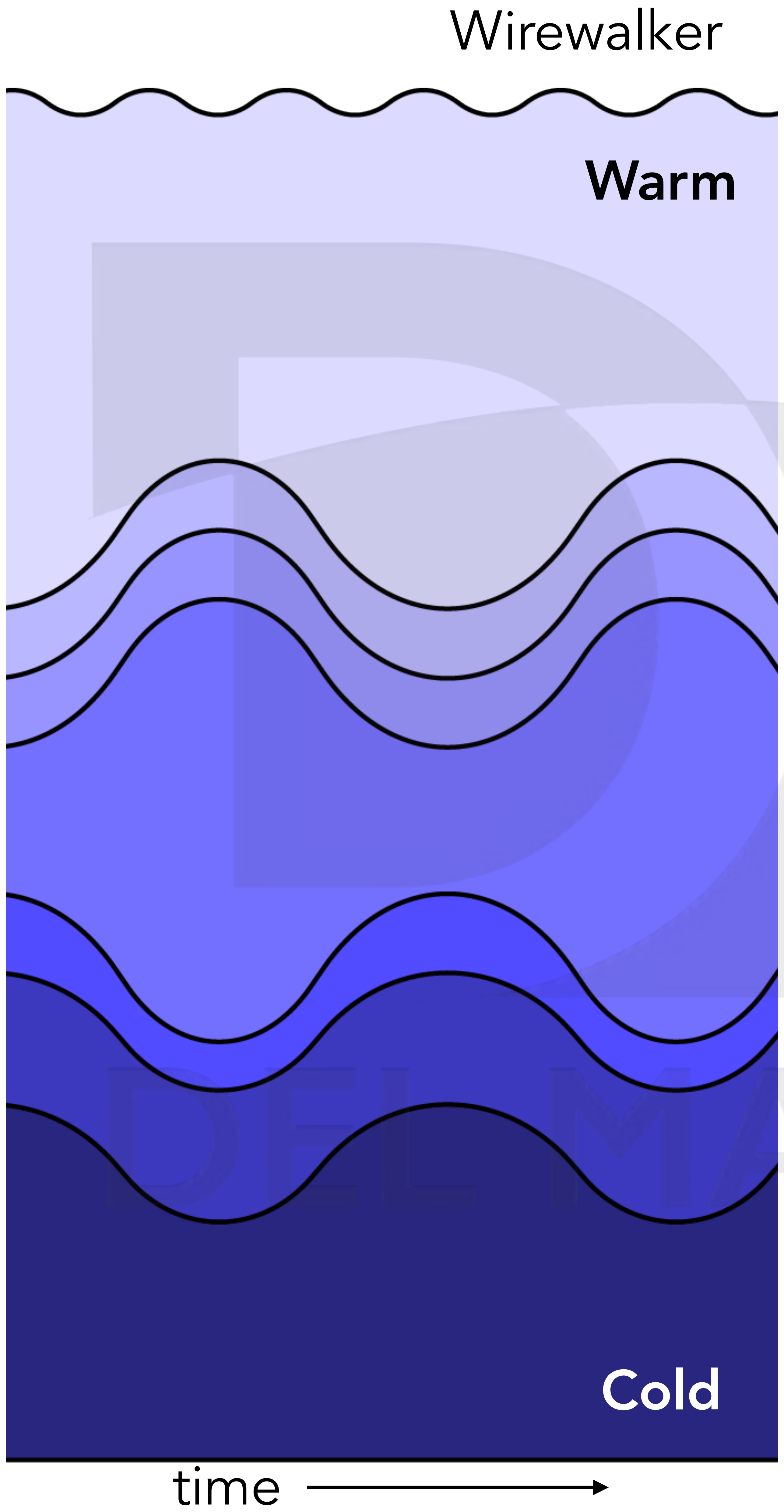
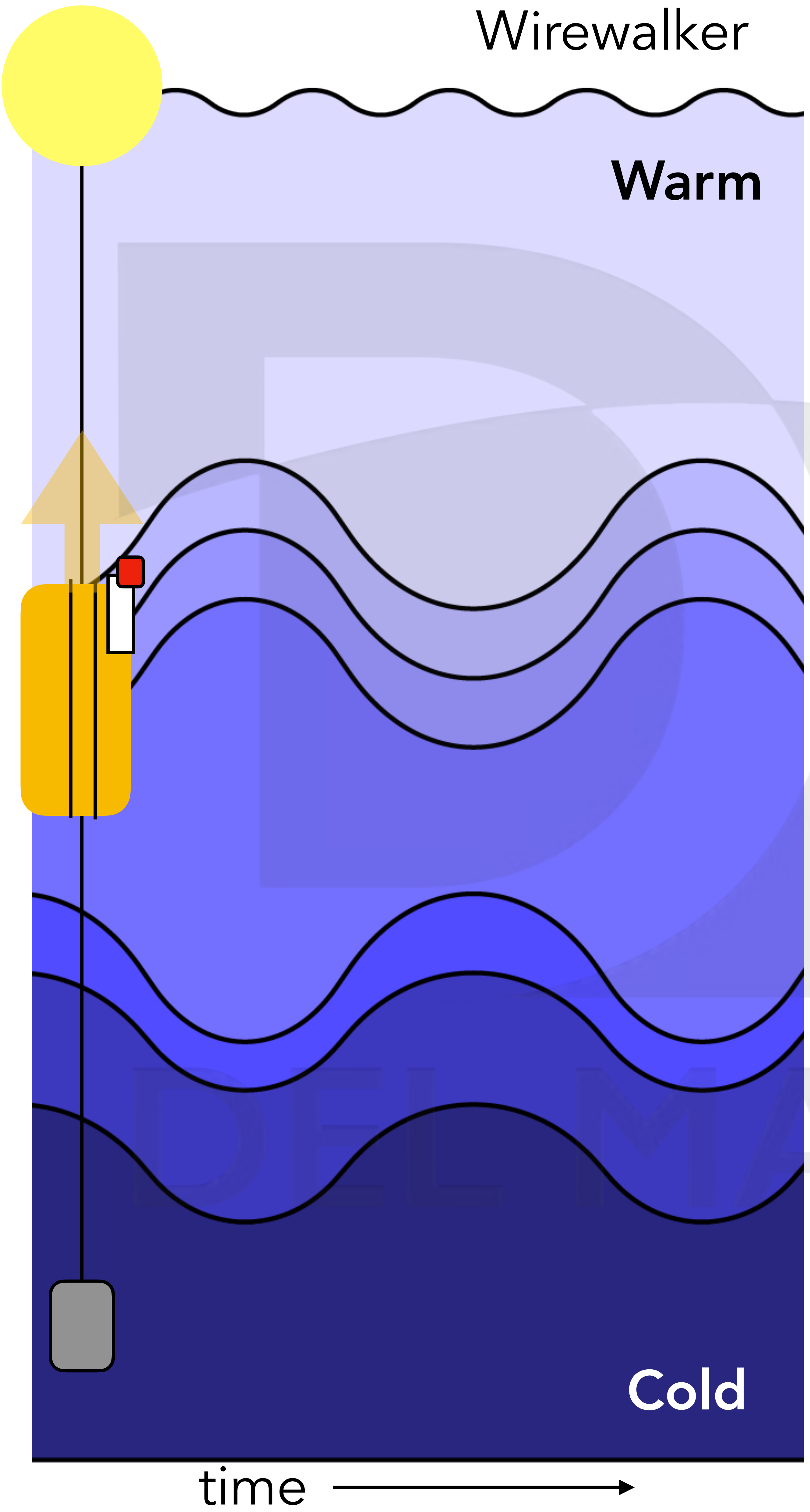


time

Why the Wirewalker?



time

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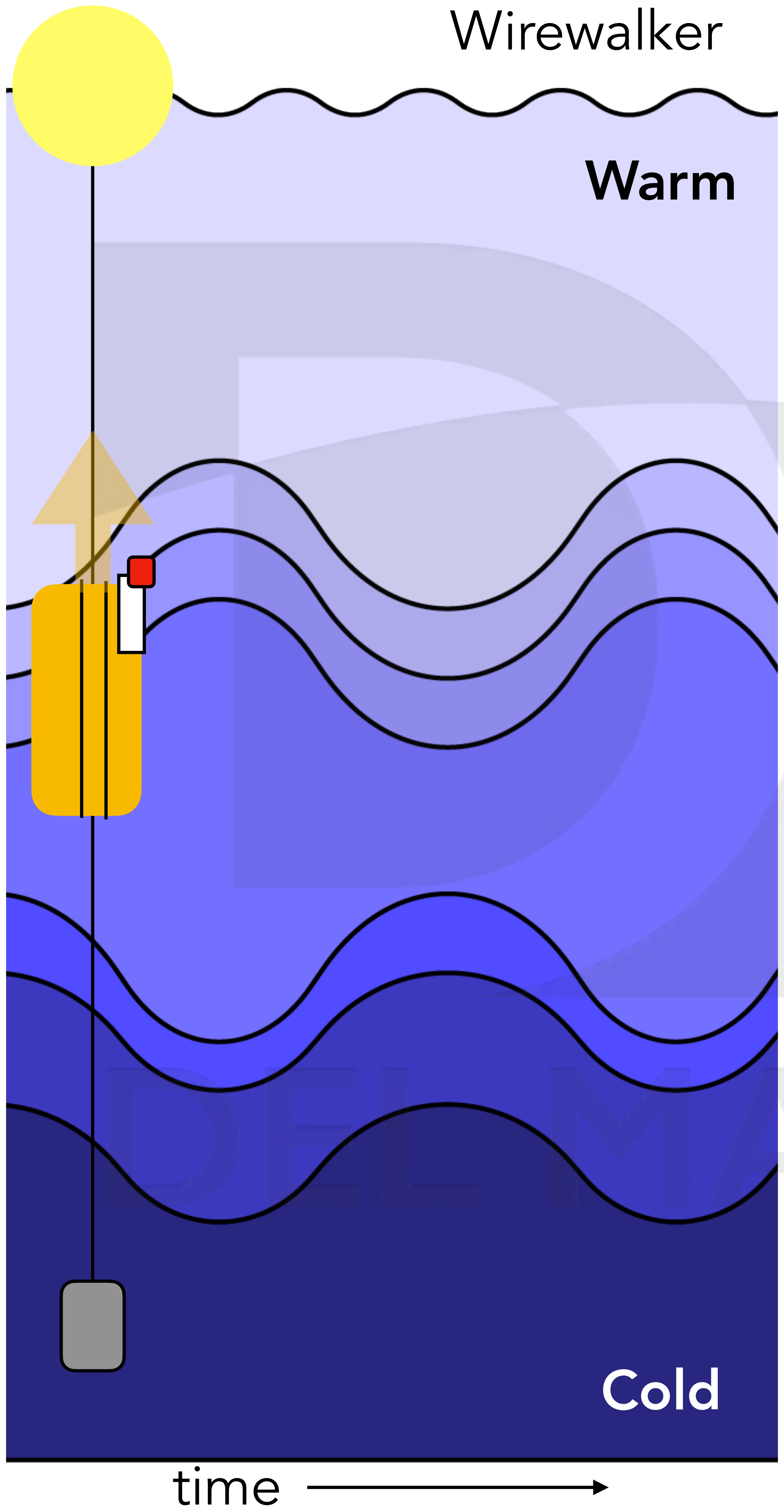

time

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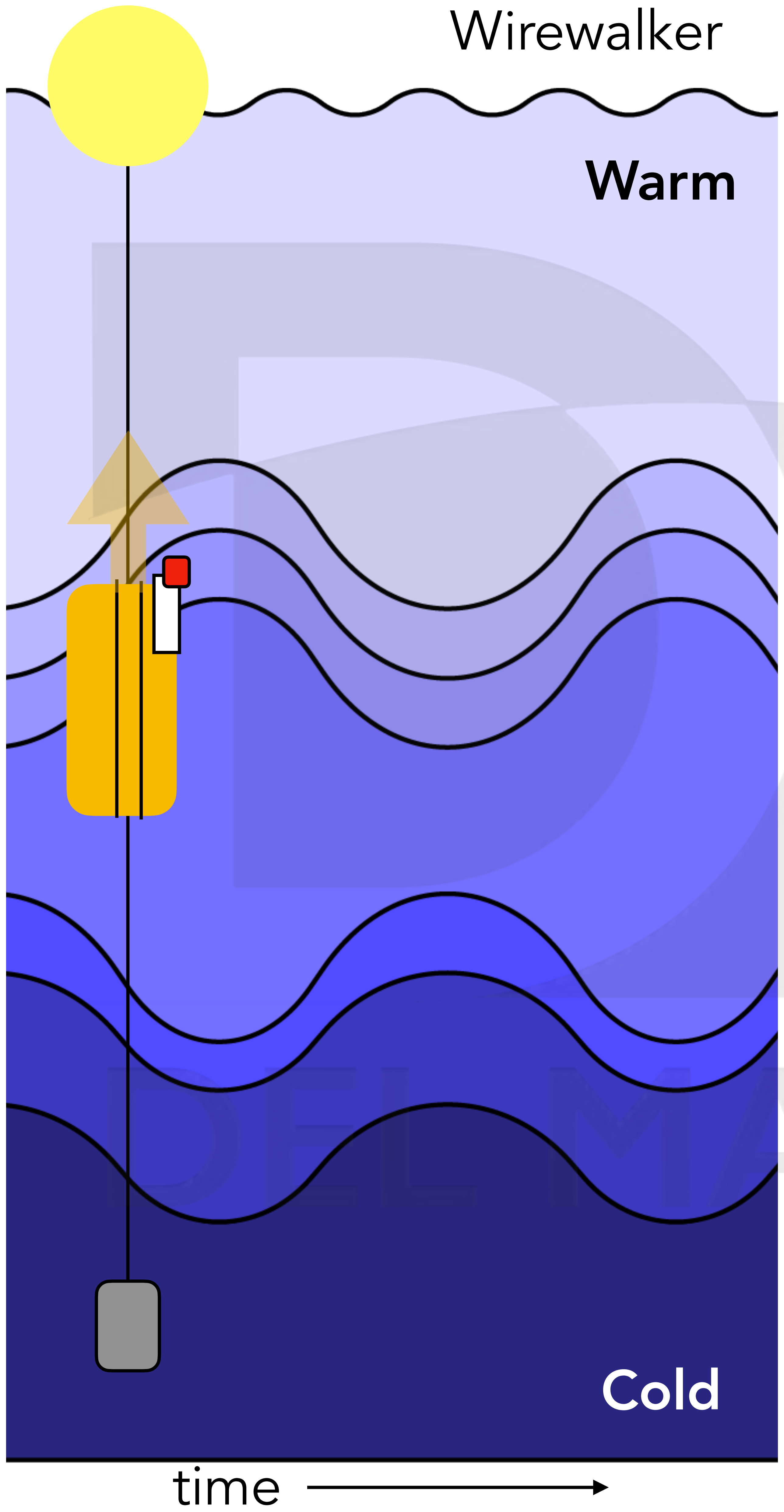

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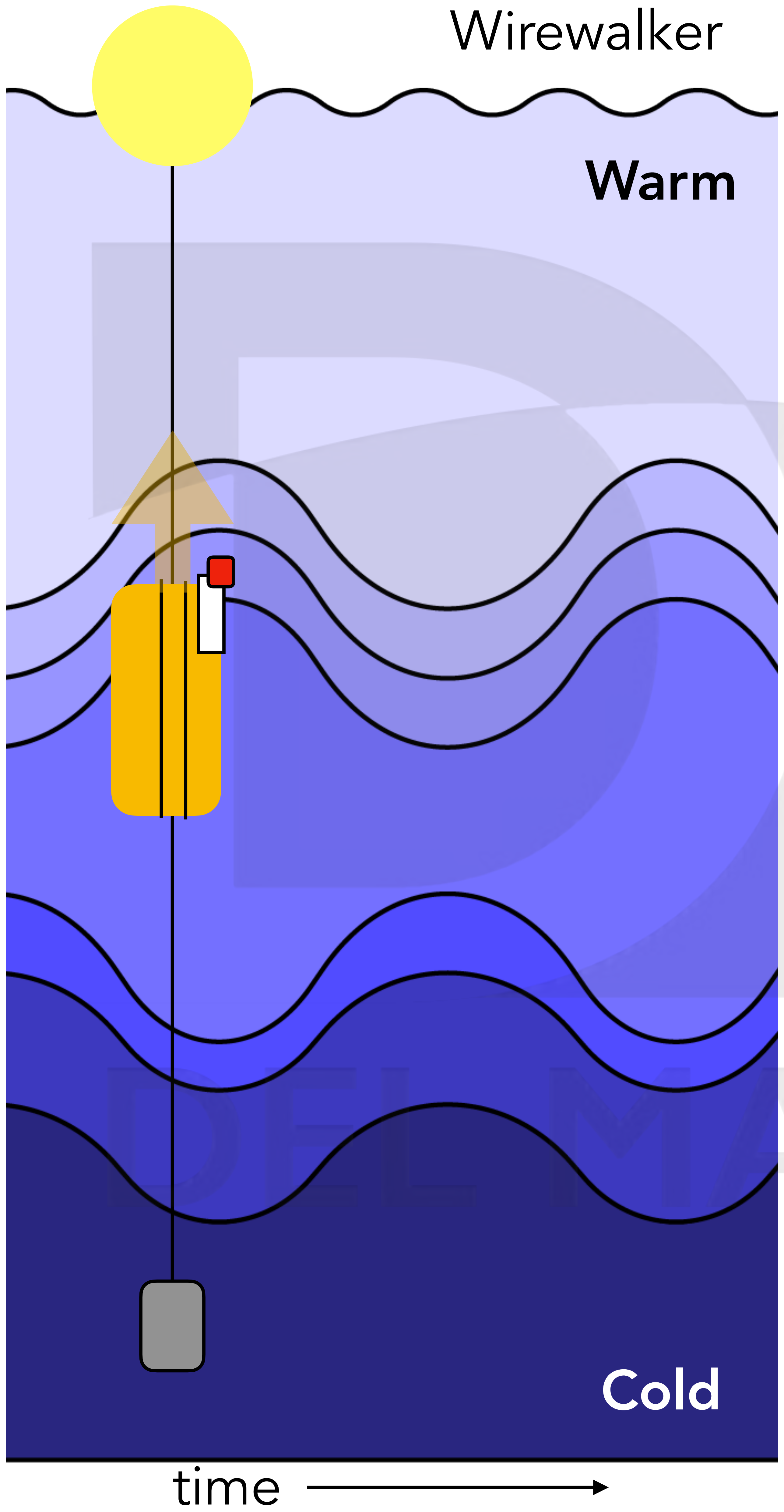

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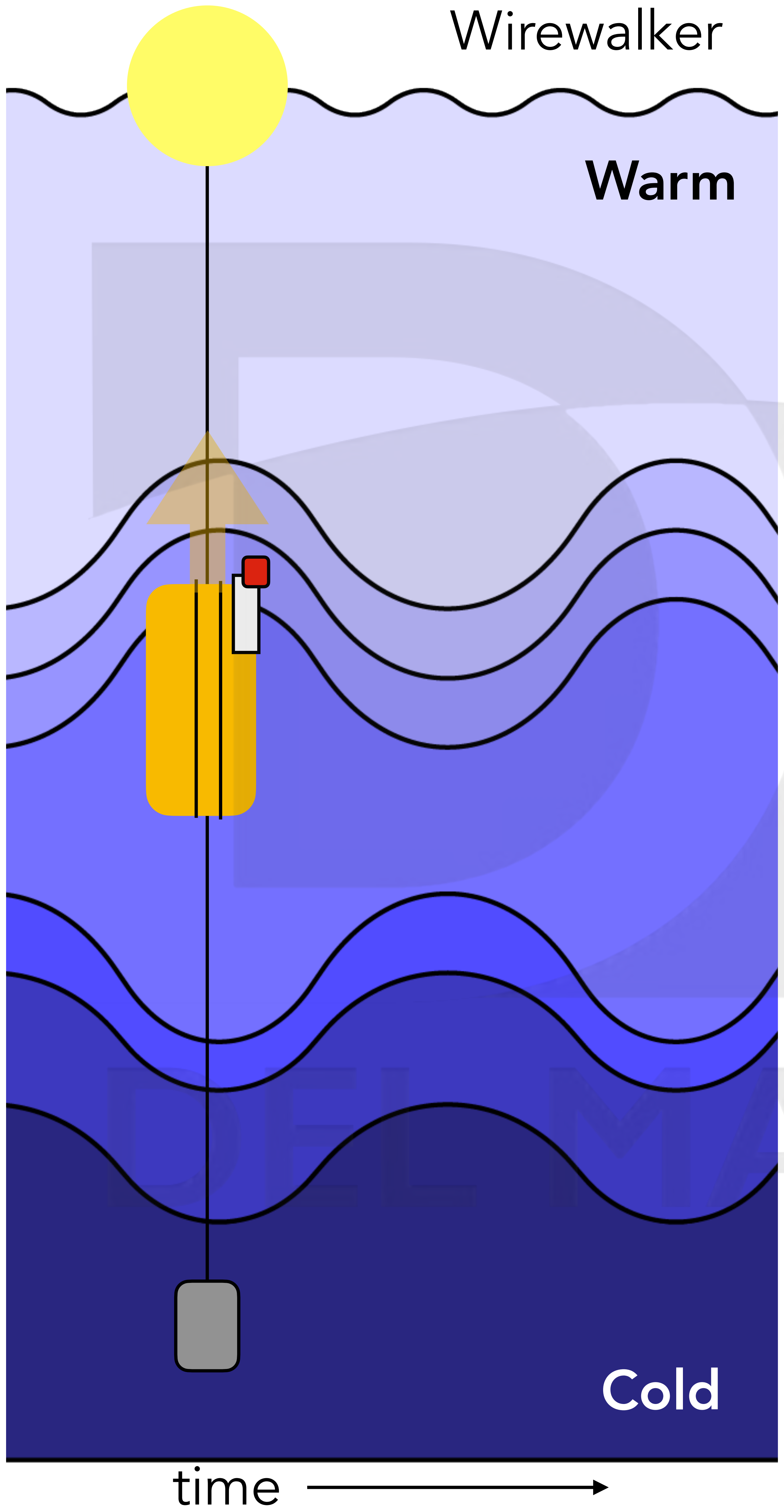

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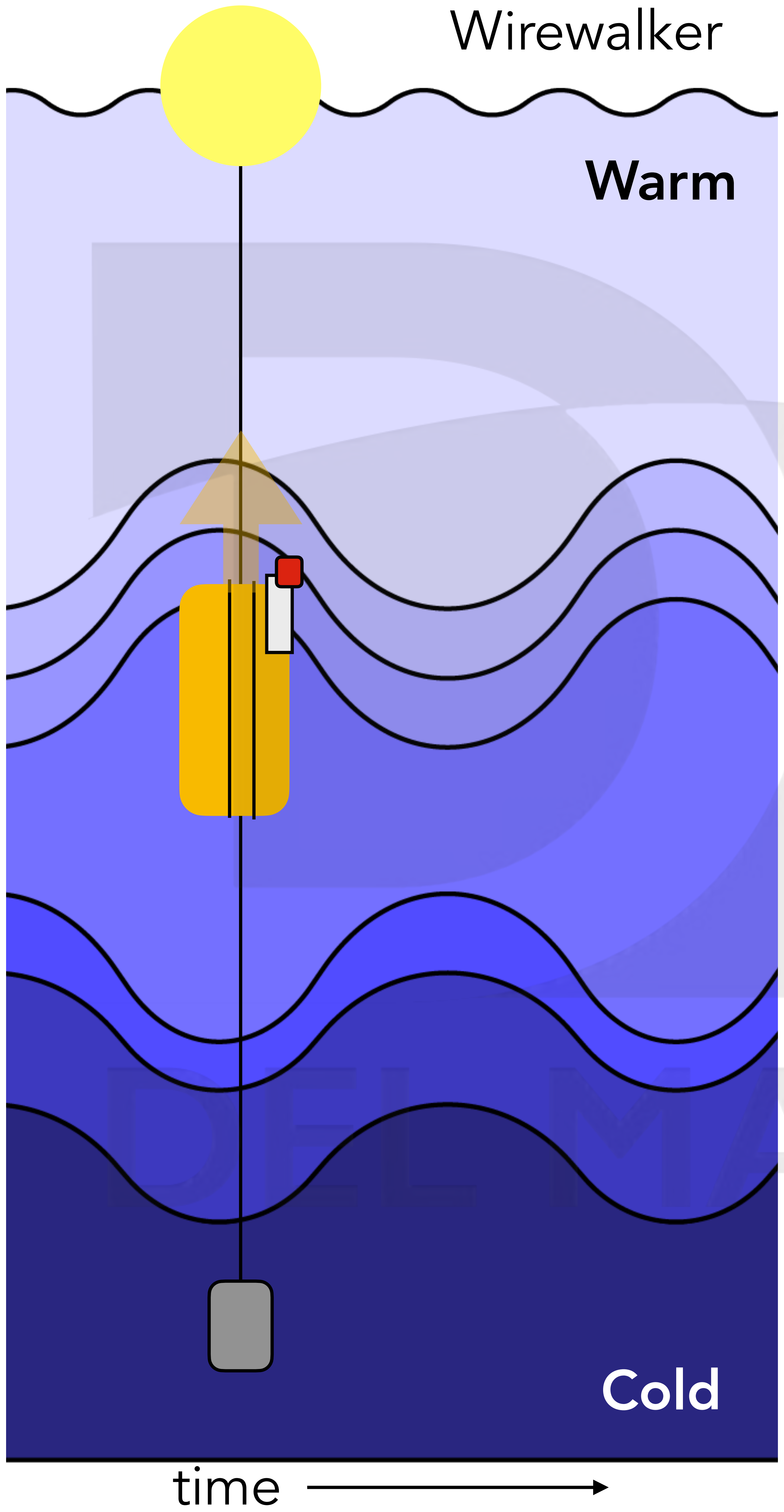

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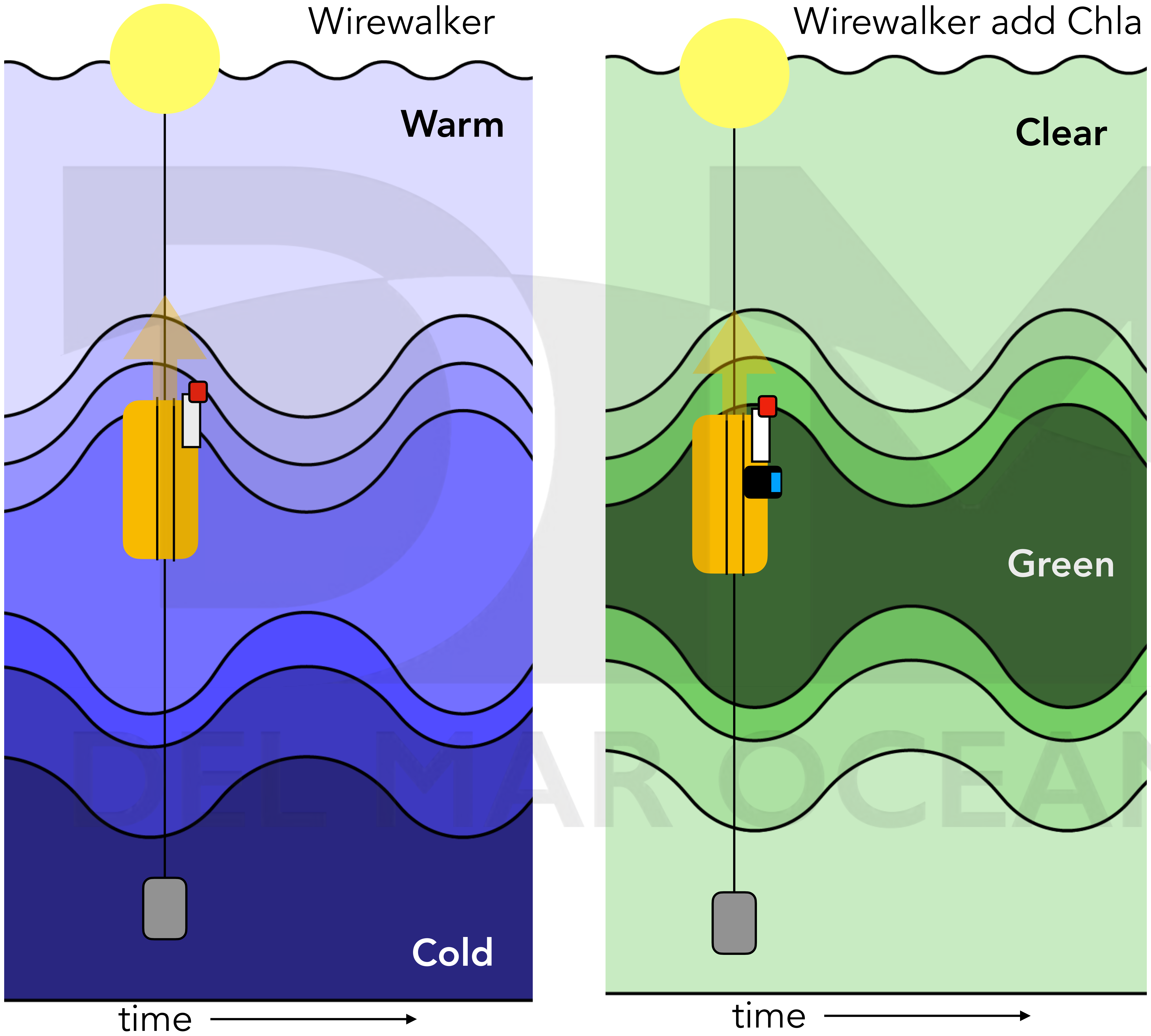

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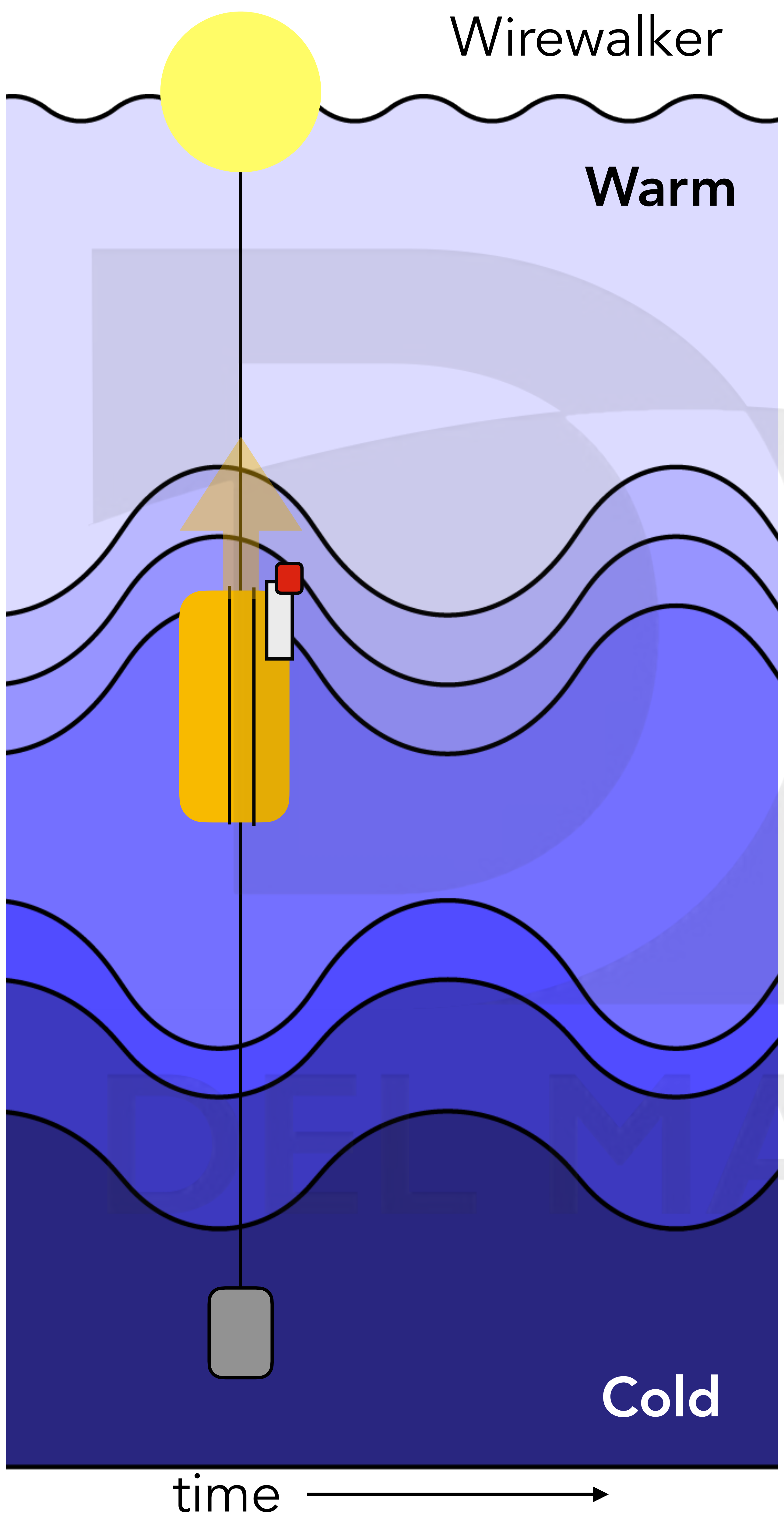
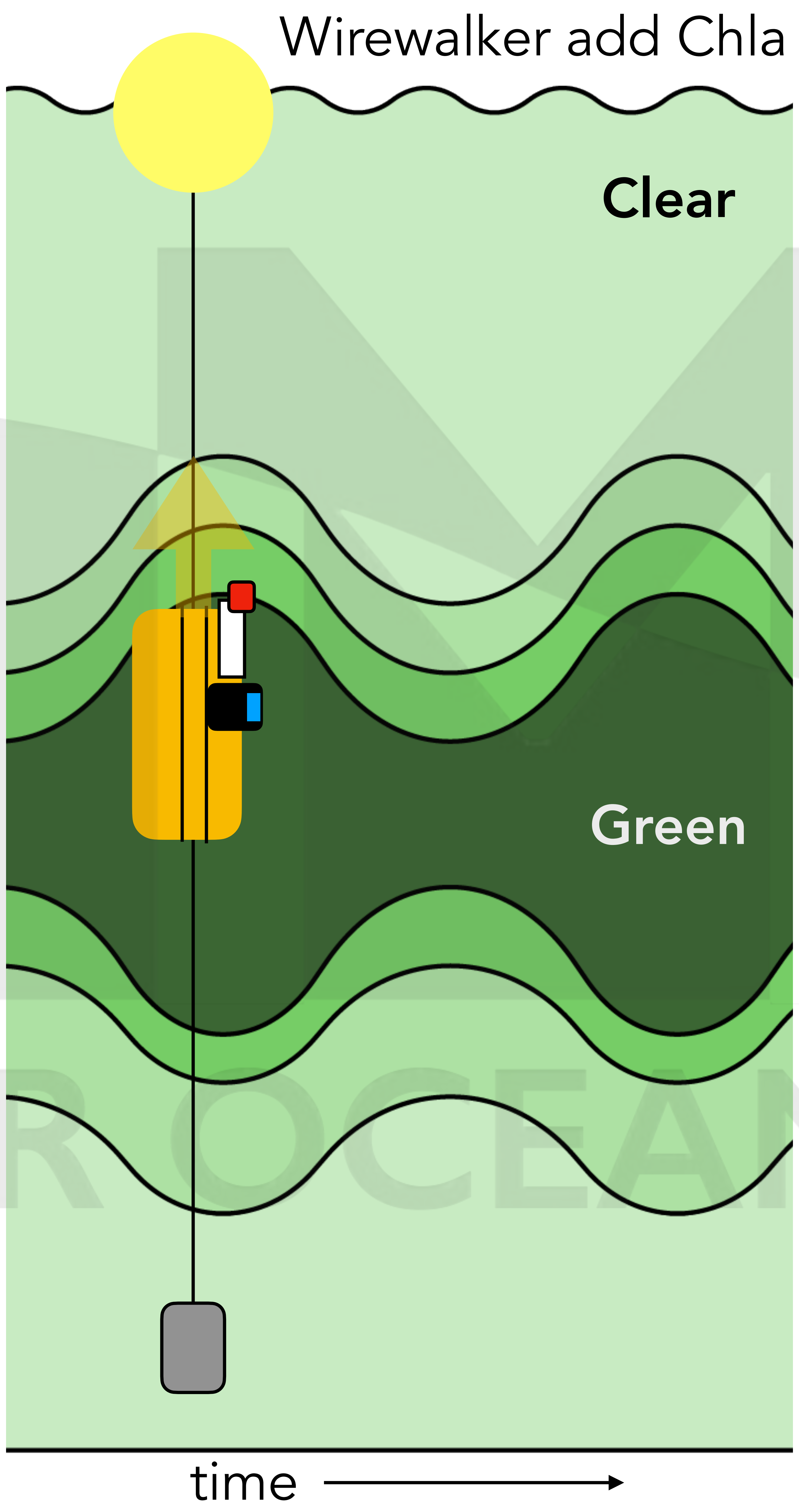




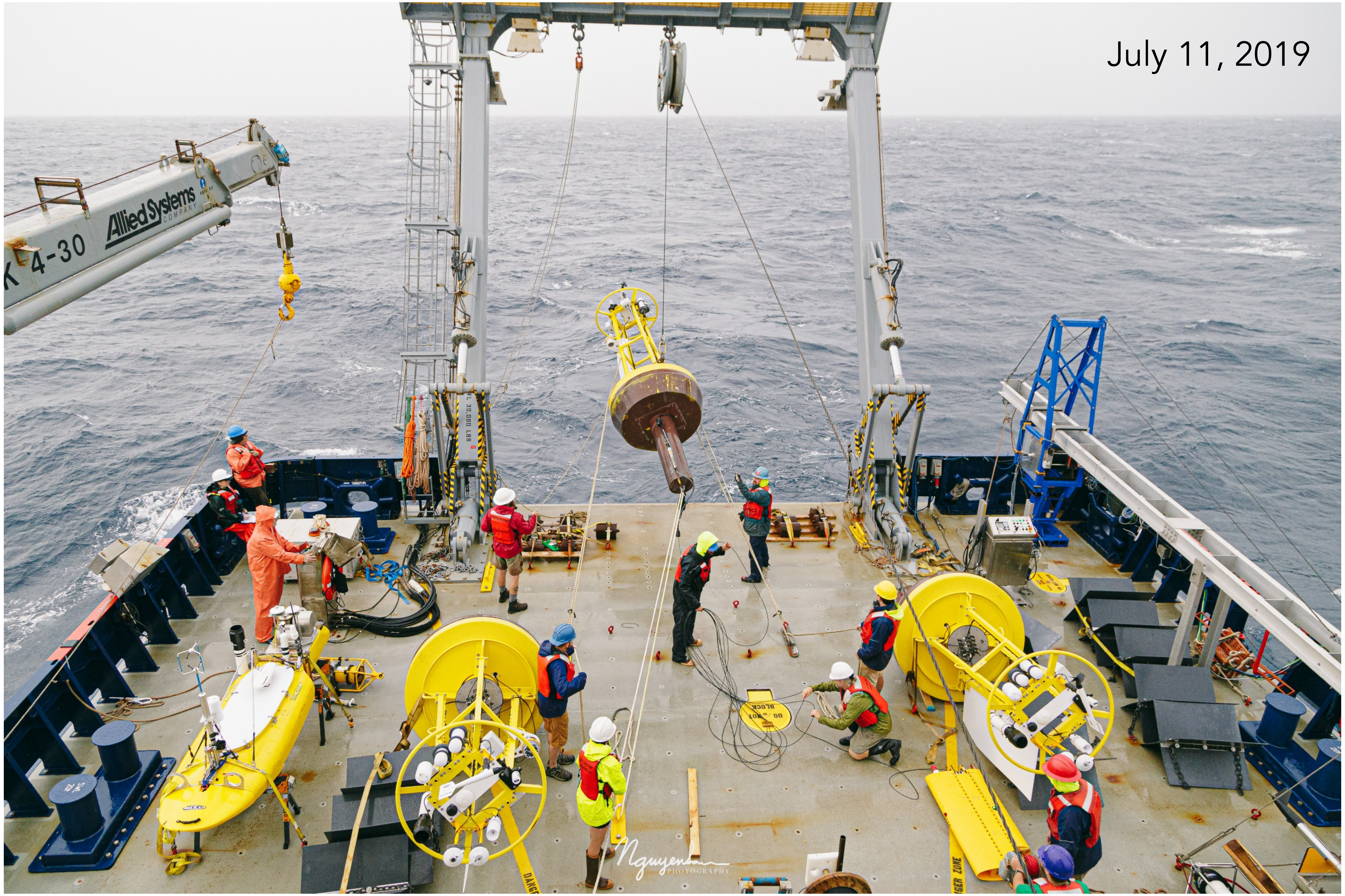
The ocean is variable in all three spatial dimensions and time.

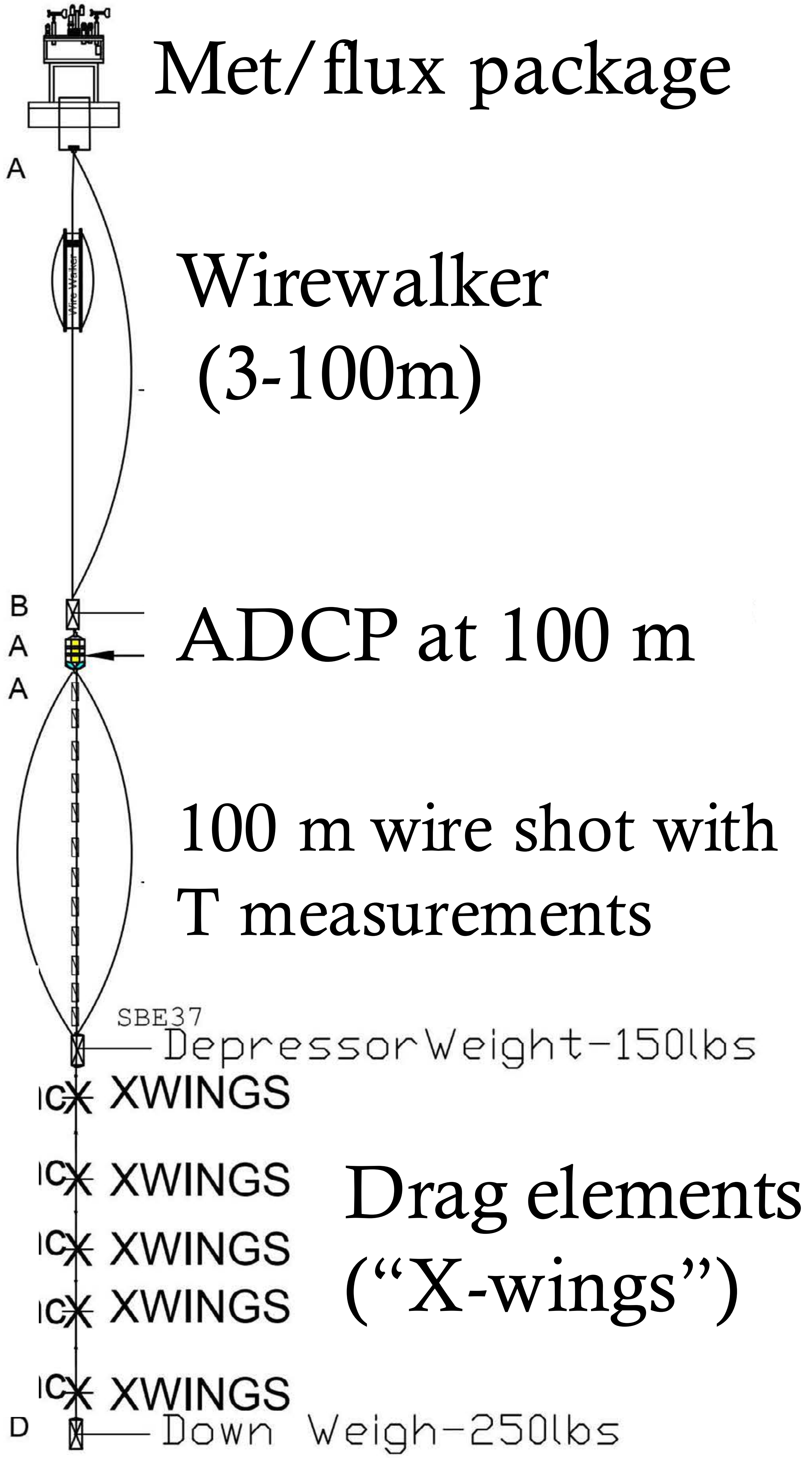
Layers in the ocean move vertically under the influence of waves and currents.

A "natural" frame of reference for the ocean is moving *with* the layers **(isopycnal frame of reference)**

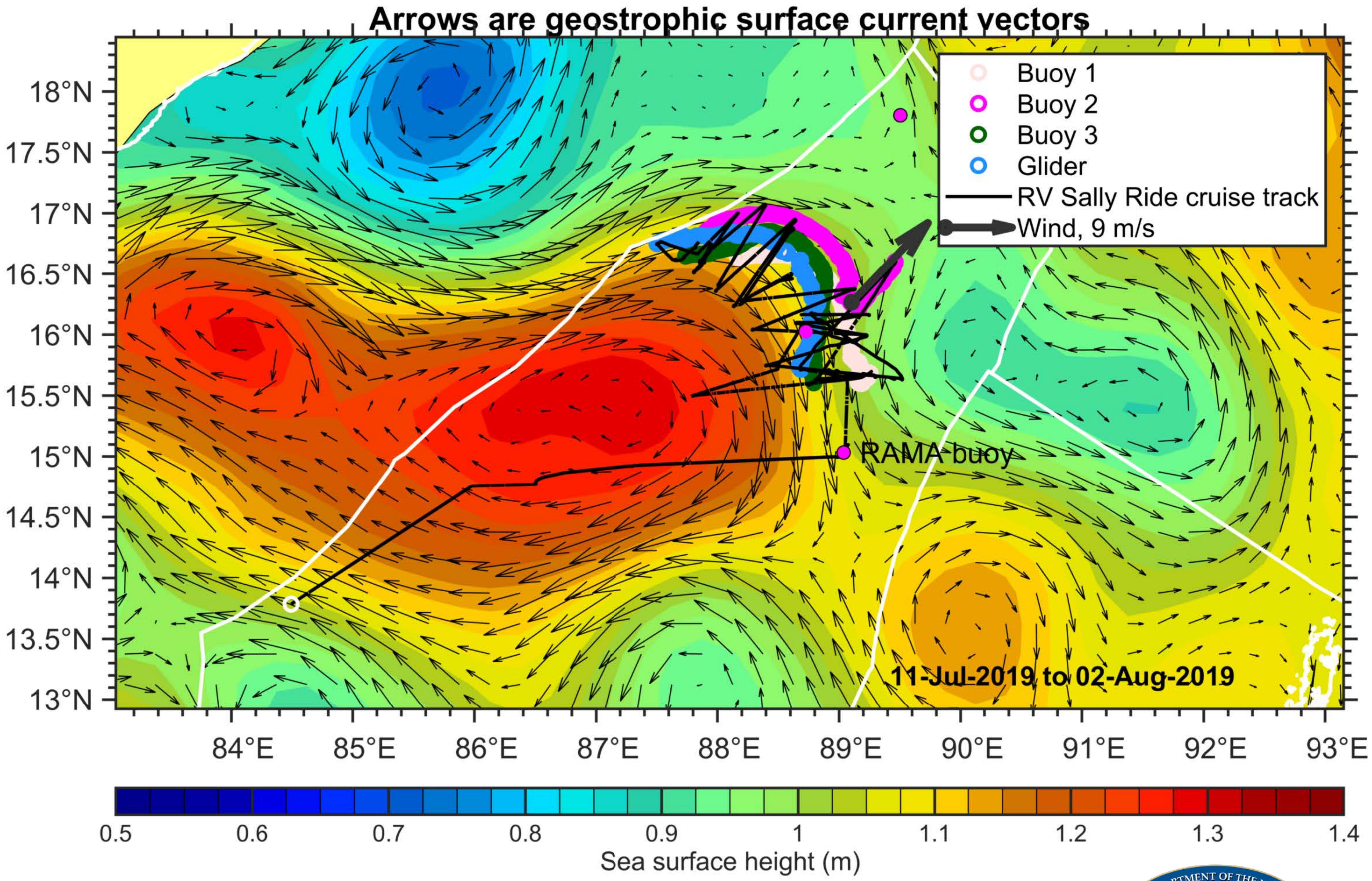
Let's take a closer look….

Wirewalker: Open-ocean color and productivity





Wirewalker: Open-ocean color and productivity



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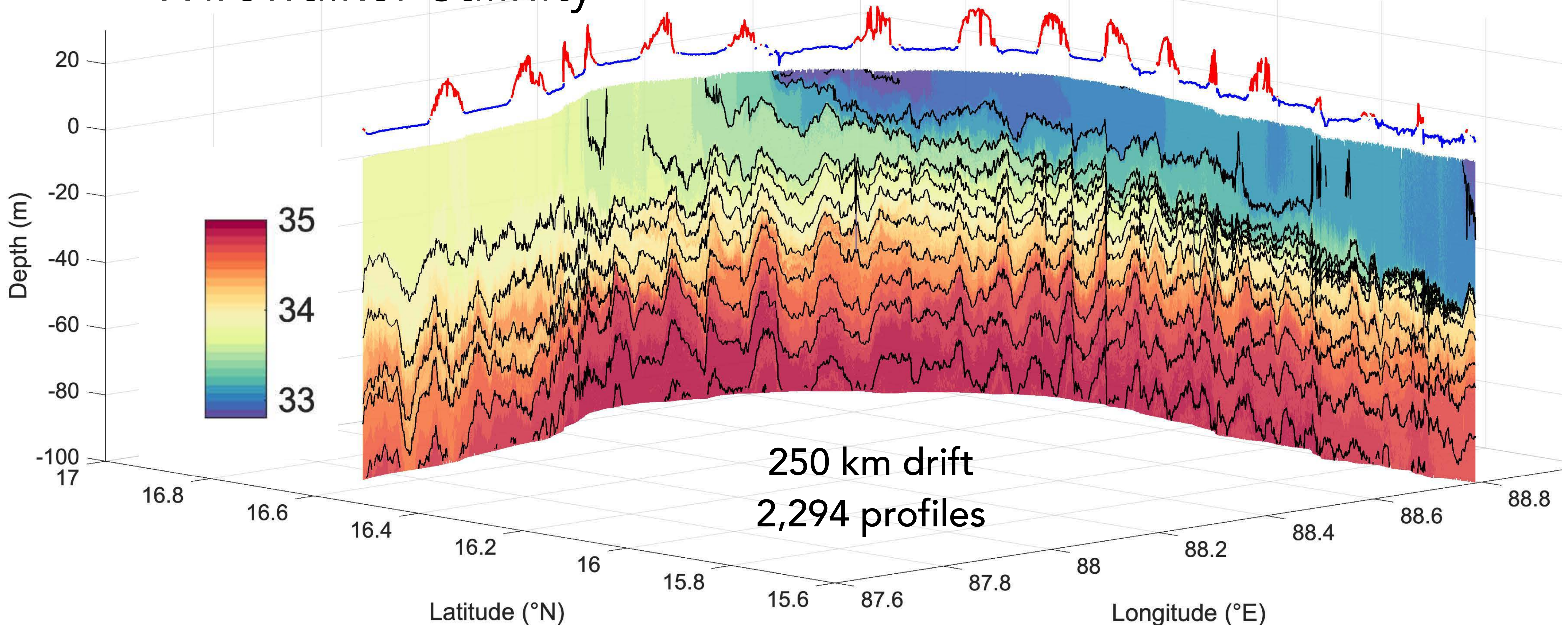
Bay of Bengal, summer 2019

Wirewalker: Open-ocean color and productivity

Wirewalker Salinity



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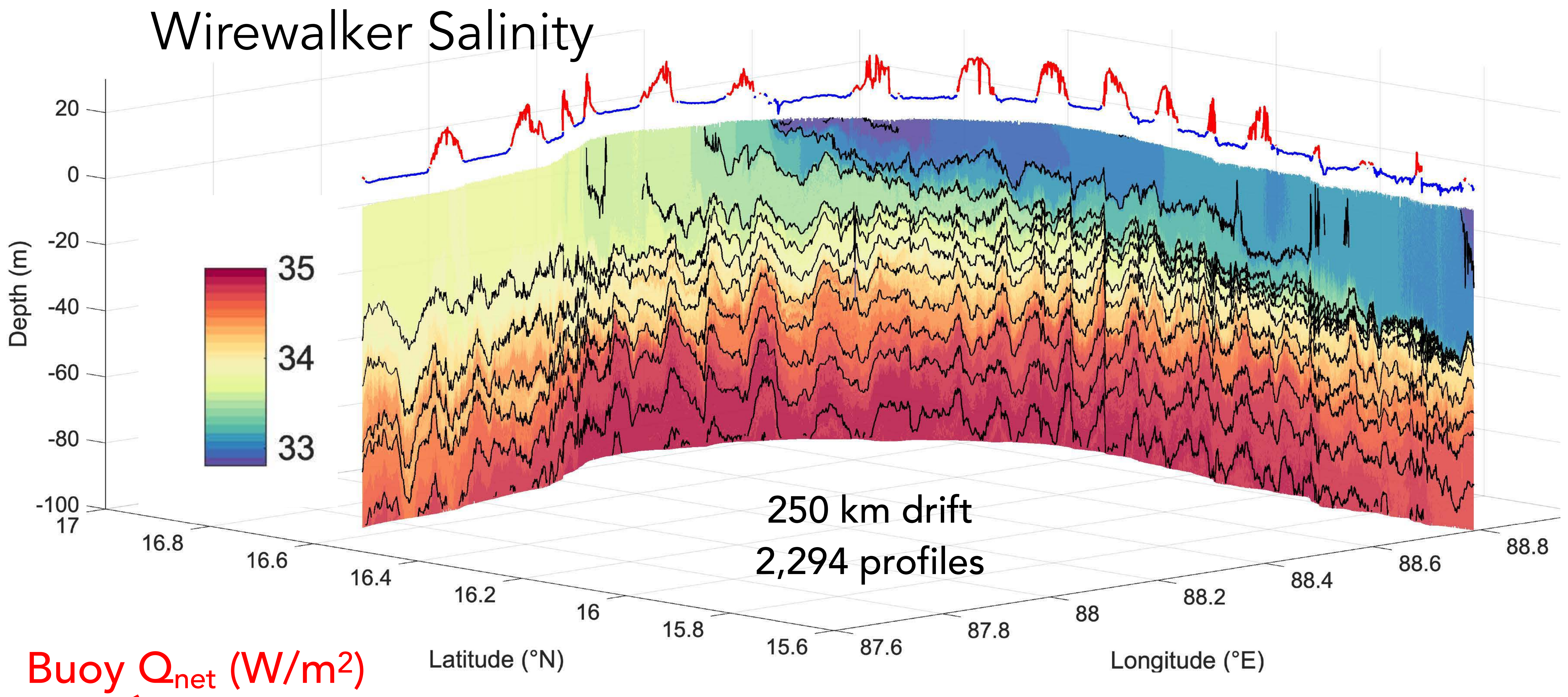
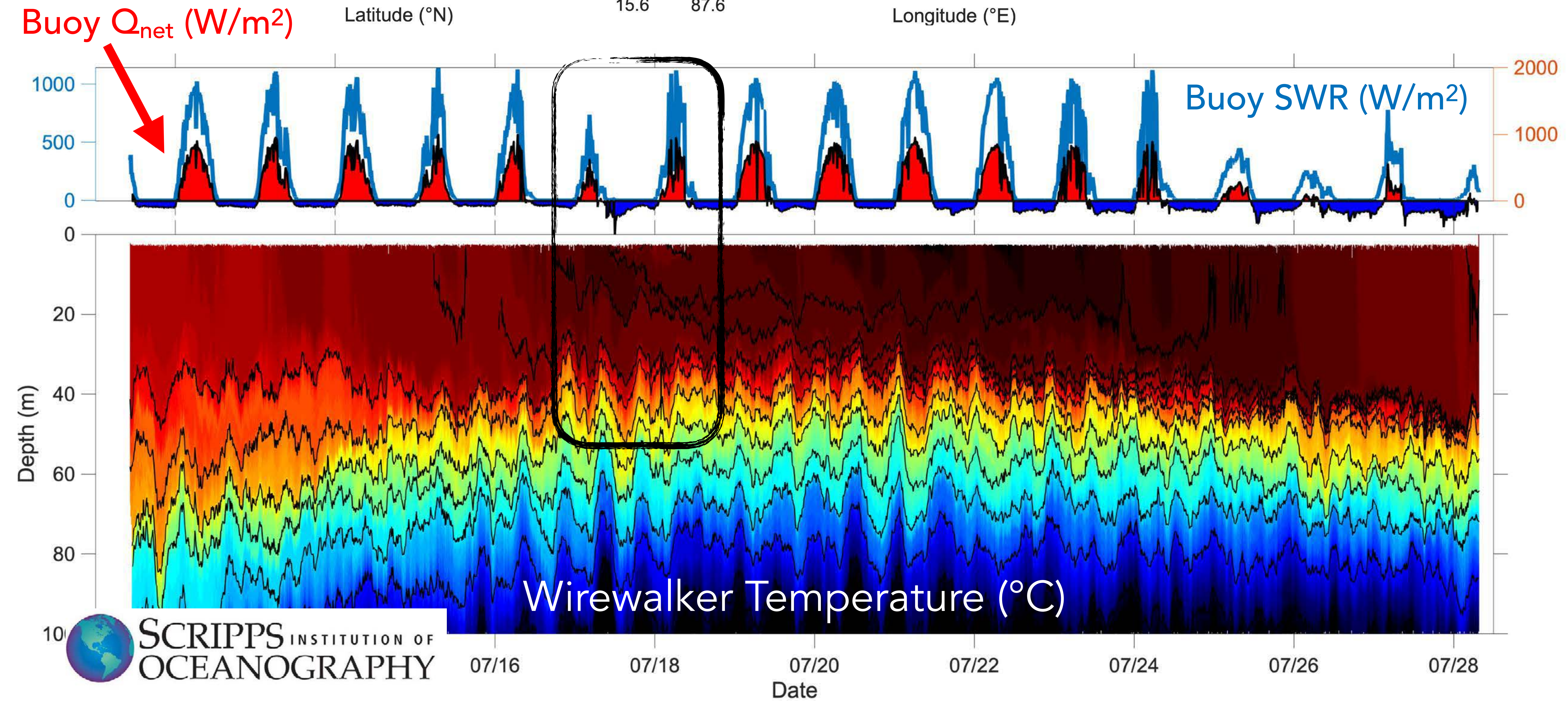
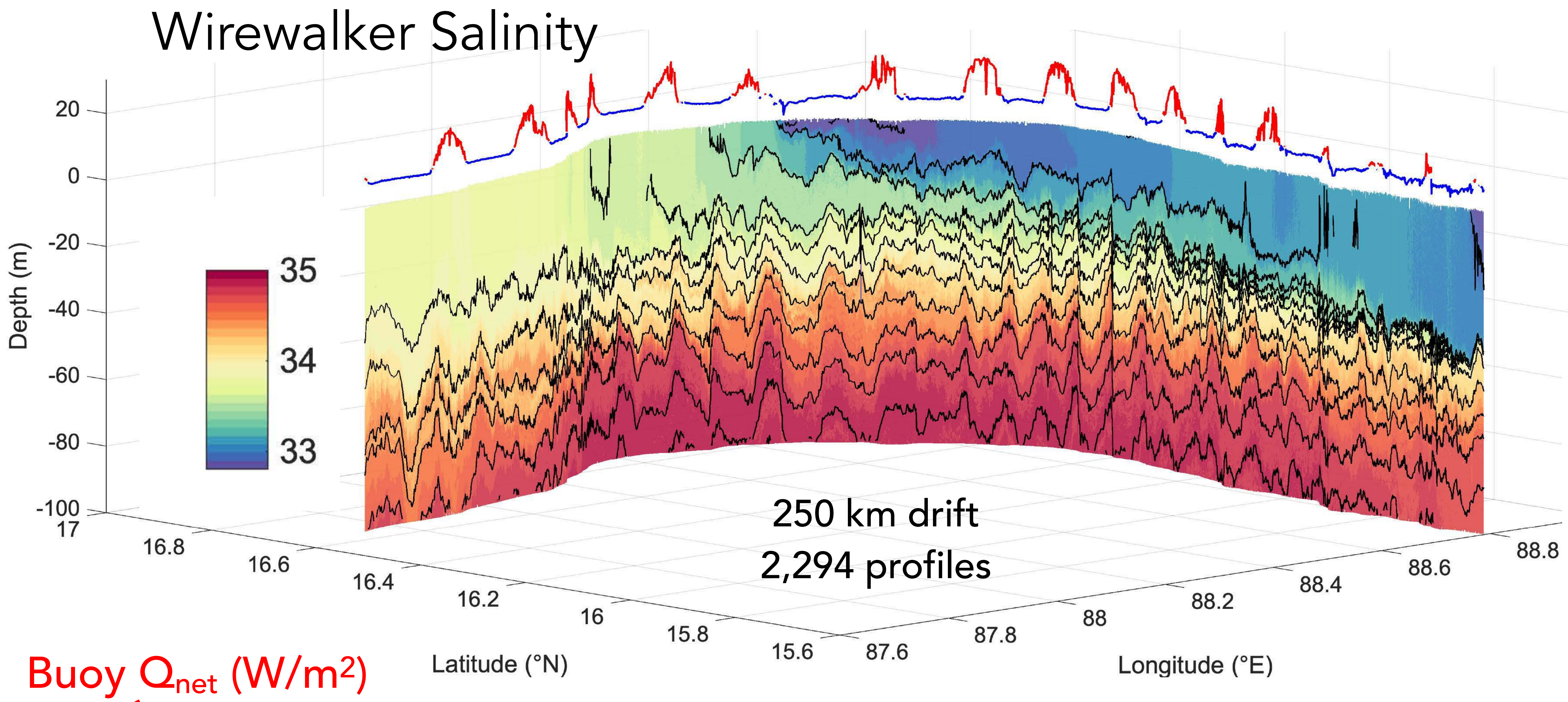
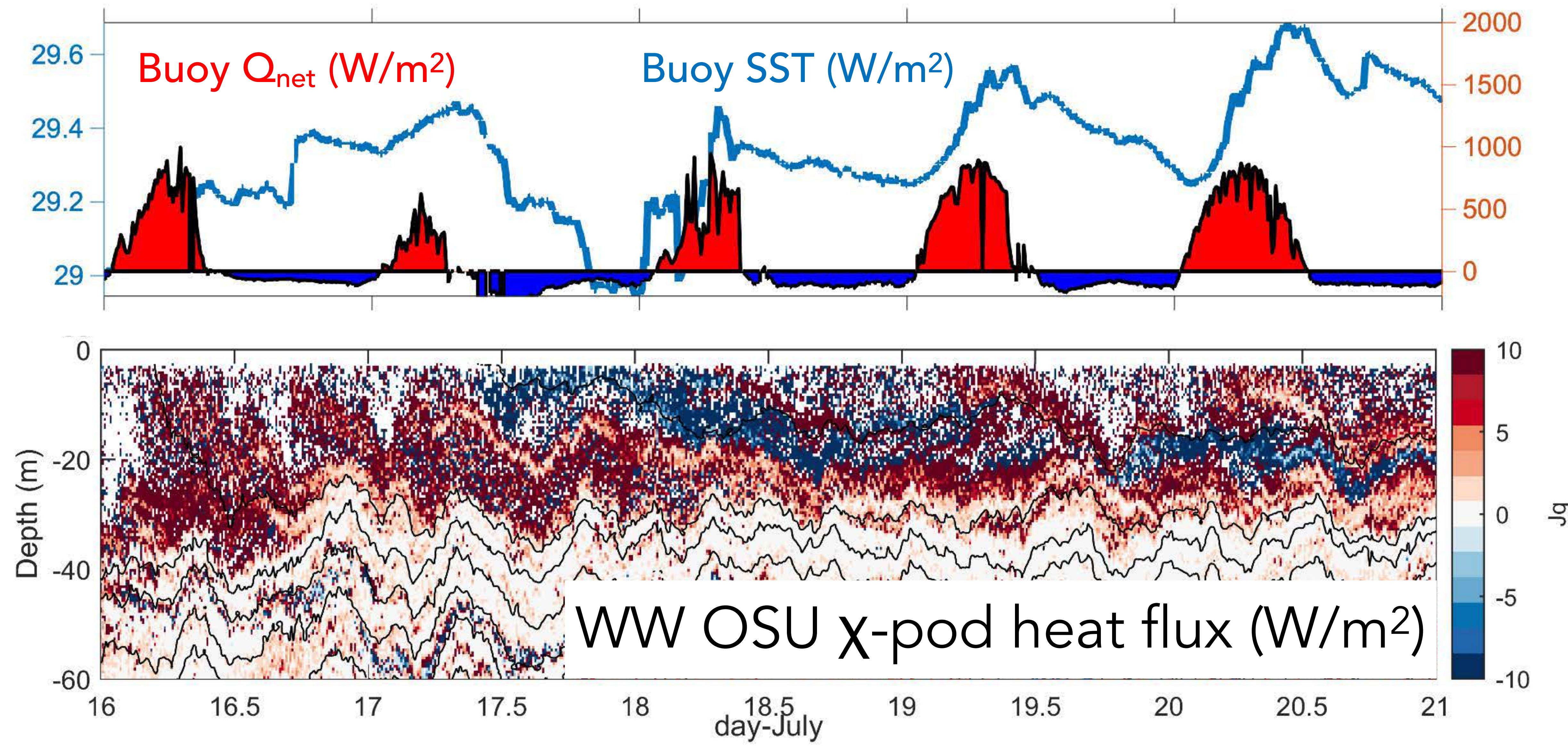
Wirewalker: Open-ocean color and productivity

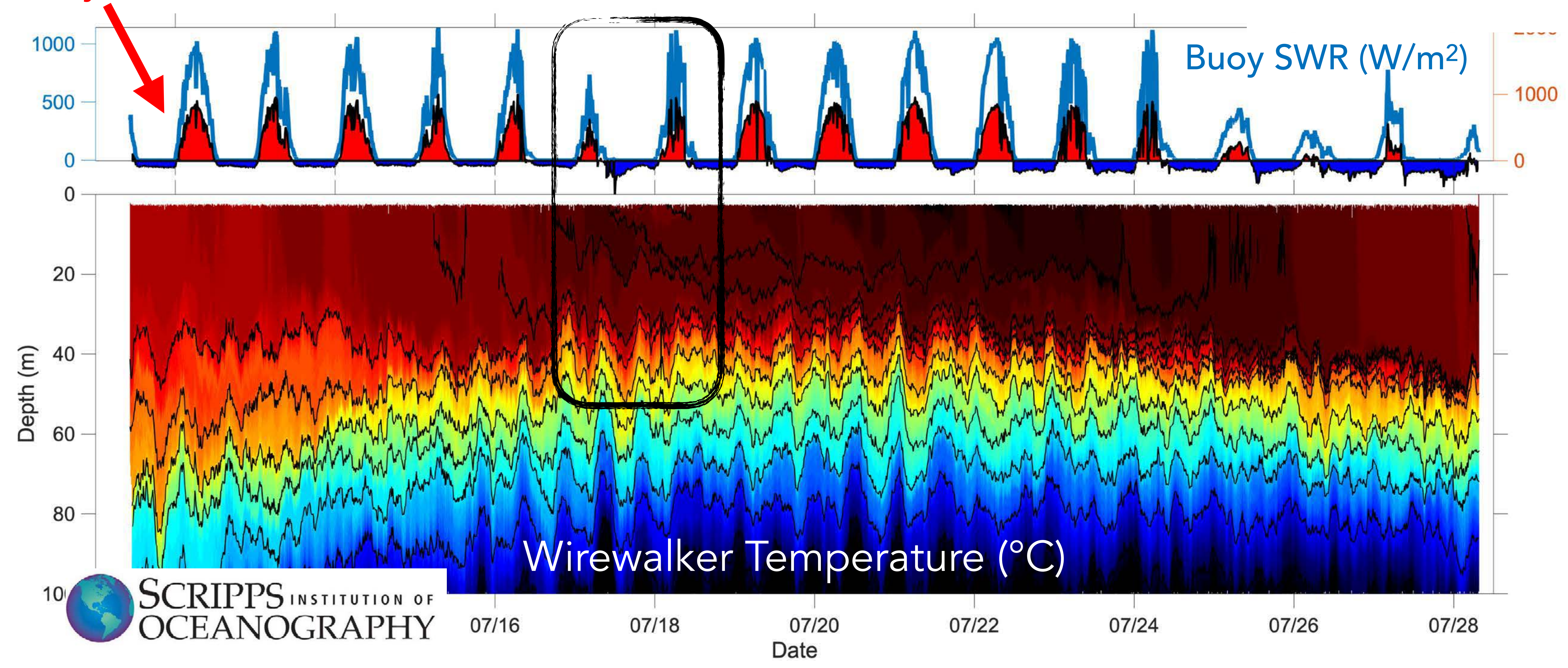




Wirewalker: Open-ocean color and productivity







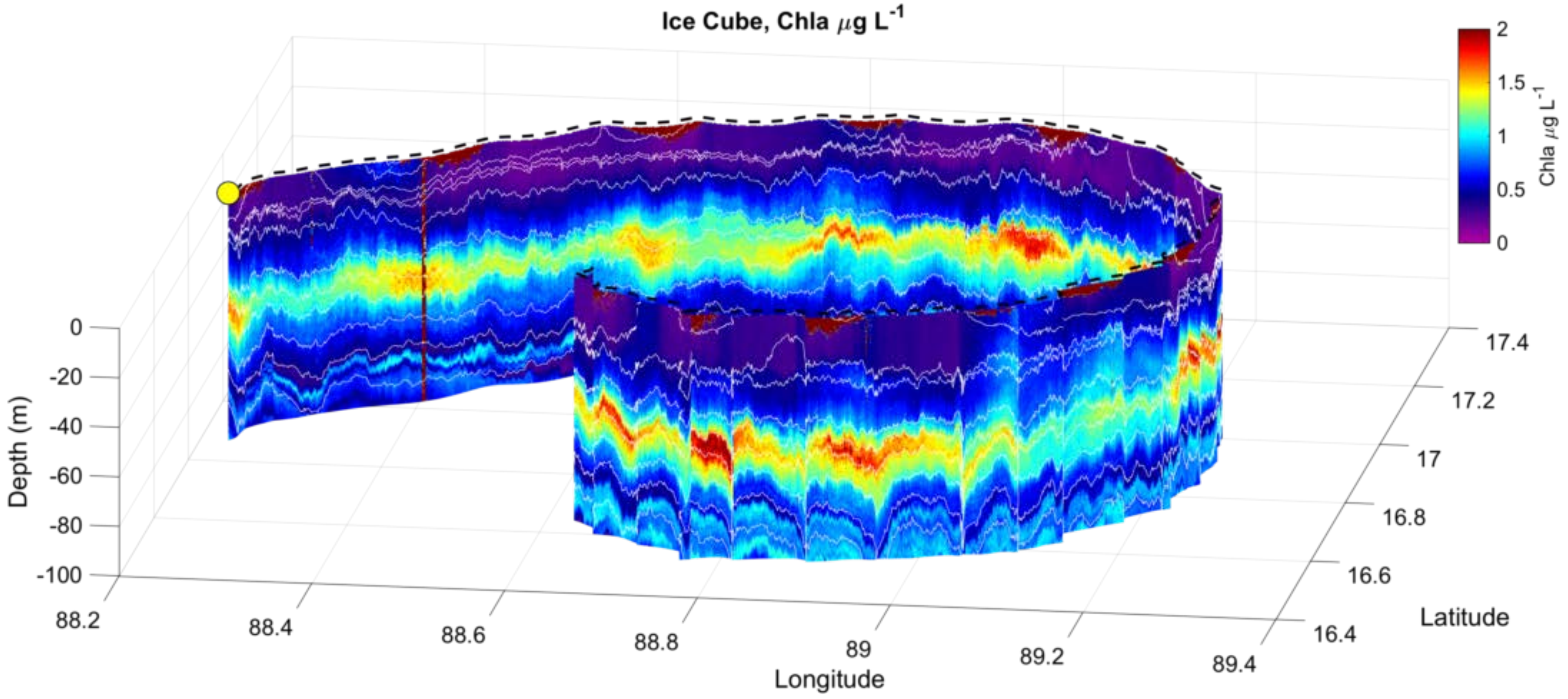
Diurnal cycling impacted by cold pool mediated latent heat loss.

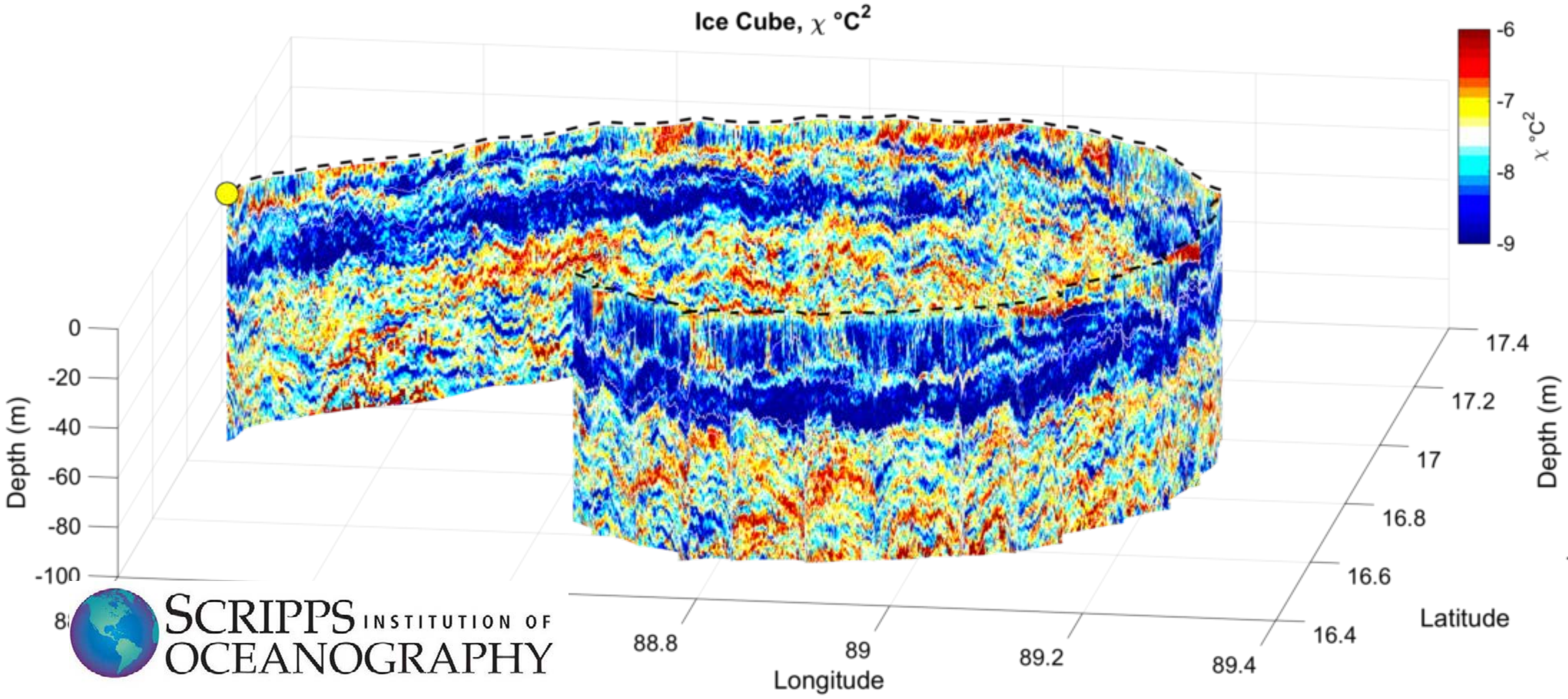
July 18 Buoy SST shows (weak) diurnal rebound, WW T(z) does not.

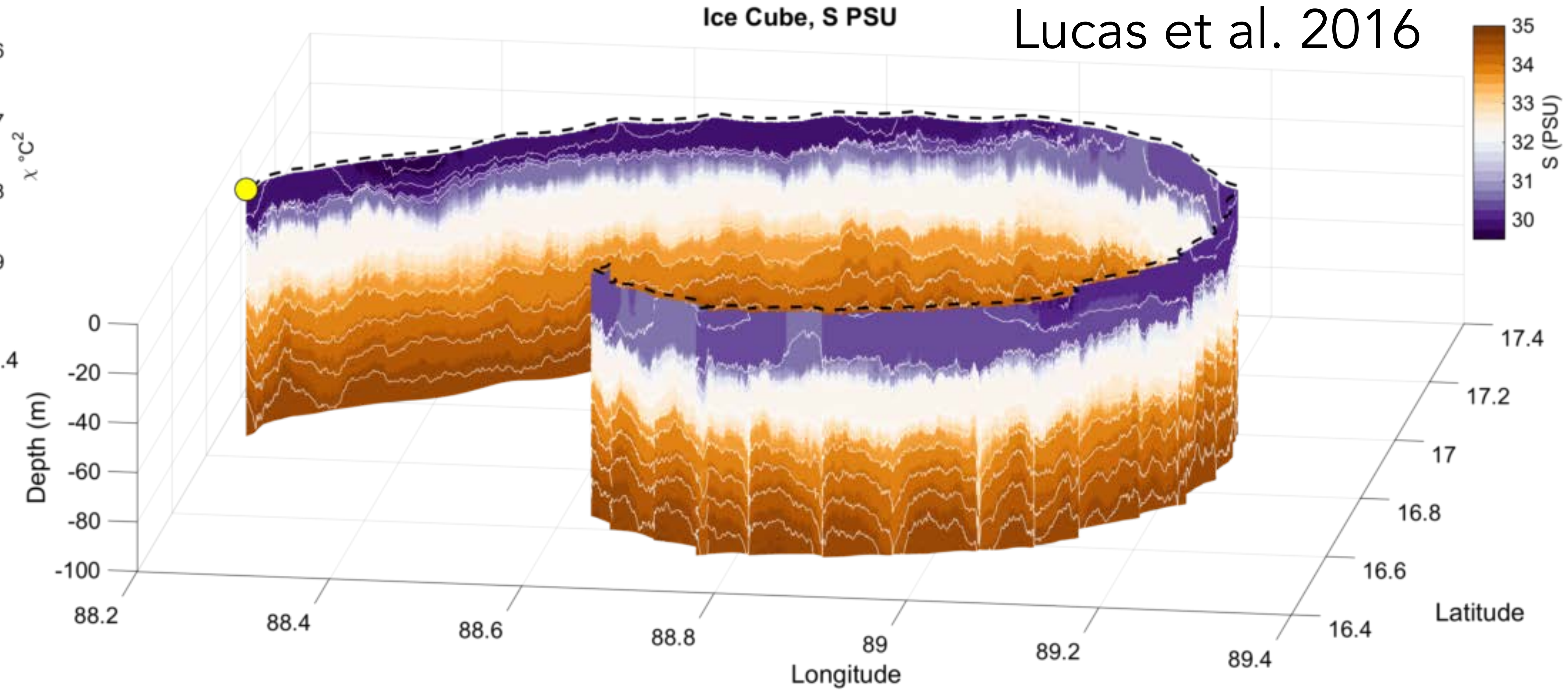
Oceanic response of downward heat flux (shear-driven?) impacts OBL heat distribution.

Wirewalker: Open-ocean color and productivity

Wirewalker open-ocean drift







Lucas et al. 2016

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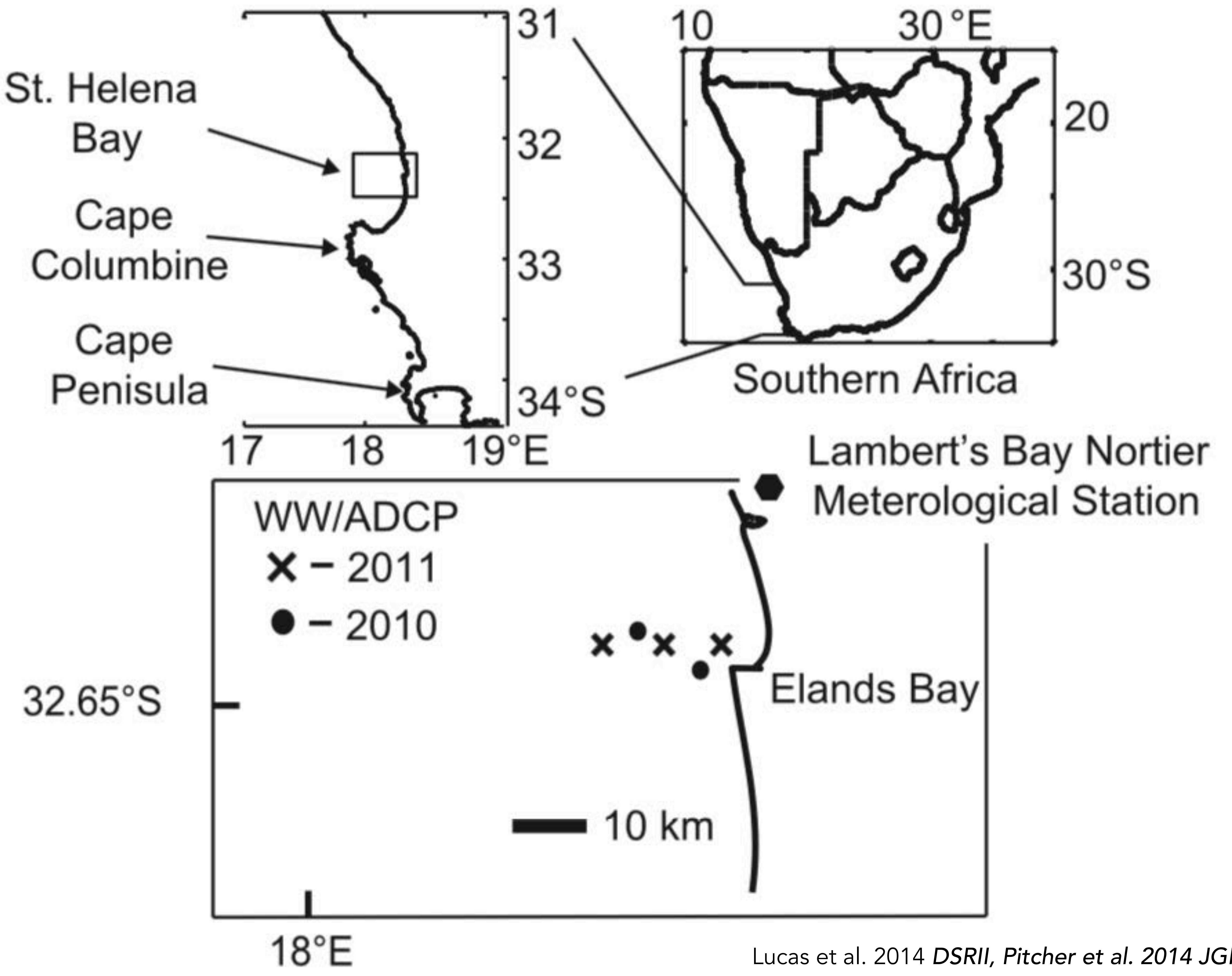
Wirewalker and the Coastal Ocean

SOUTH AFRICA 2010/2011 Mooring array



Lucas et al. 2014 *DSRII, Pitcher et al. 2014 JGR*
See also **Lucas et al. 2011,** Limnol. Ocean.

acknowledgements: UCT and DAFF

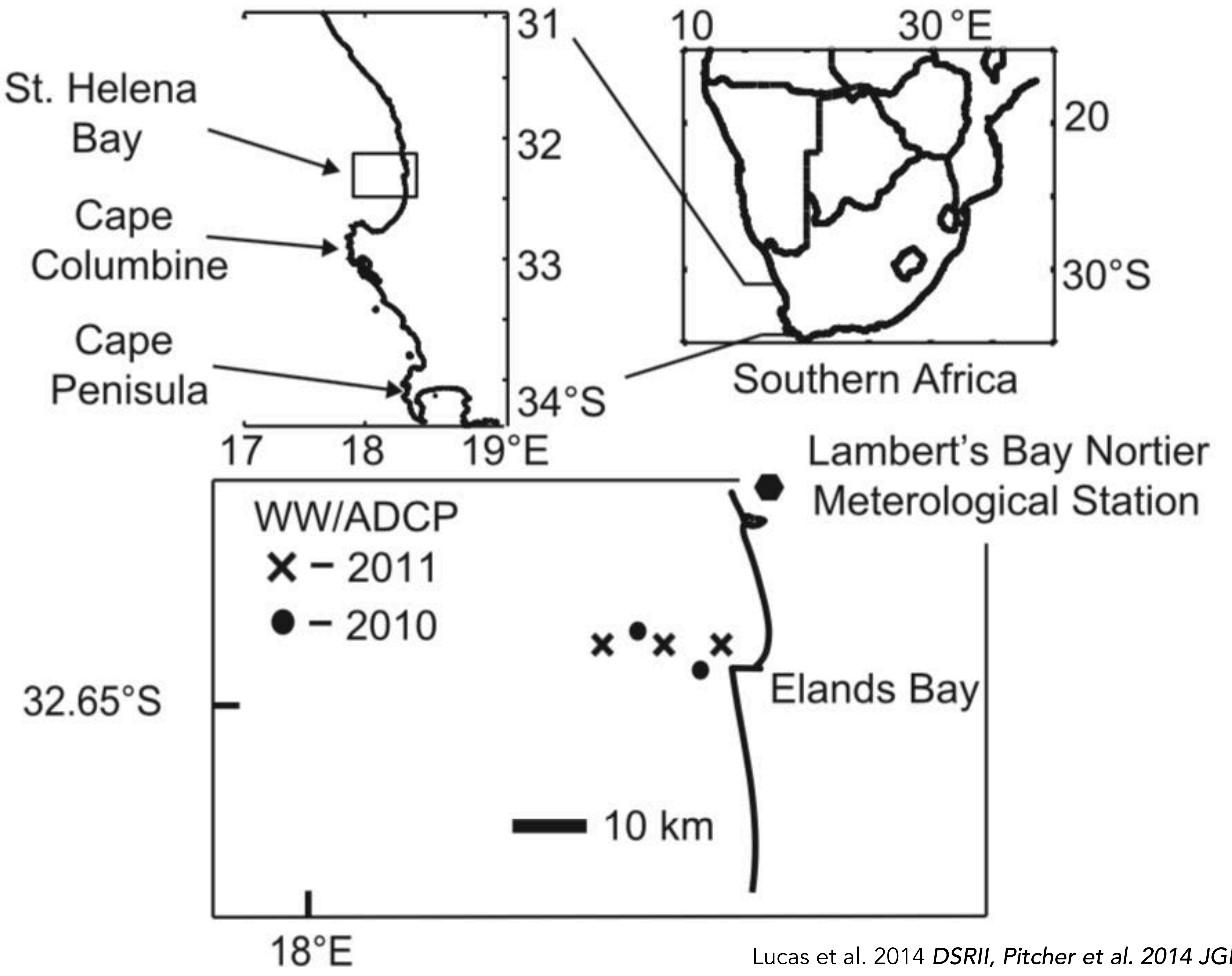
Wirewalker wave-powered profiling vehicle

The Wirewalker is a SIO-developed wave-powered vertical profiler.

WW has a flexible payload, with rapid profiling powered by environmental energy.

Wirewalker and the Coastal Ocean

SOUTH AFRICA 2010/2011 Mooring array



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Wirewalker and the Coastal Ocean

Wirewalker observations

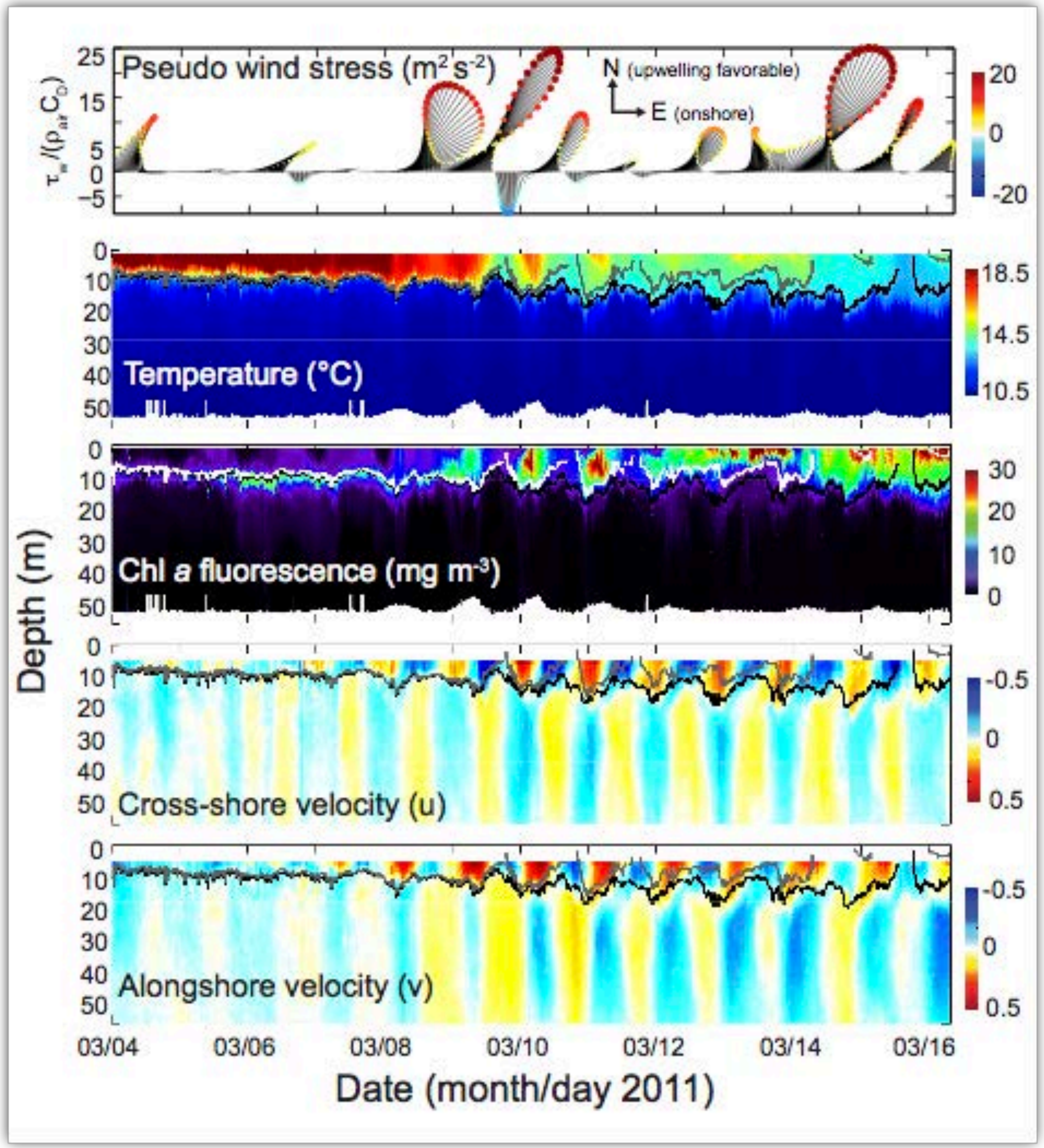
Wirewalker and the Coastal Ocean

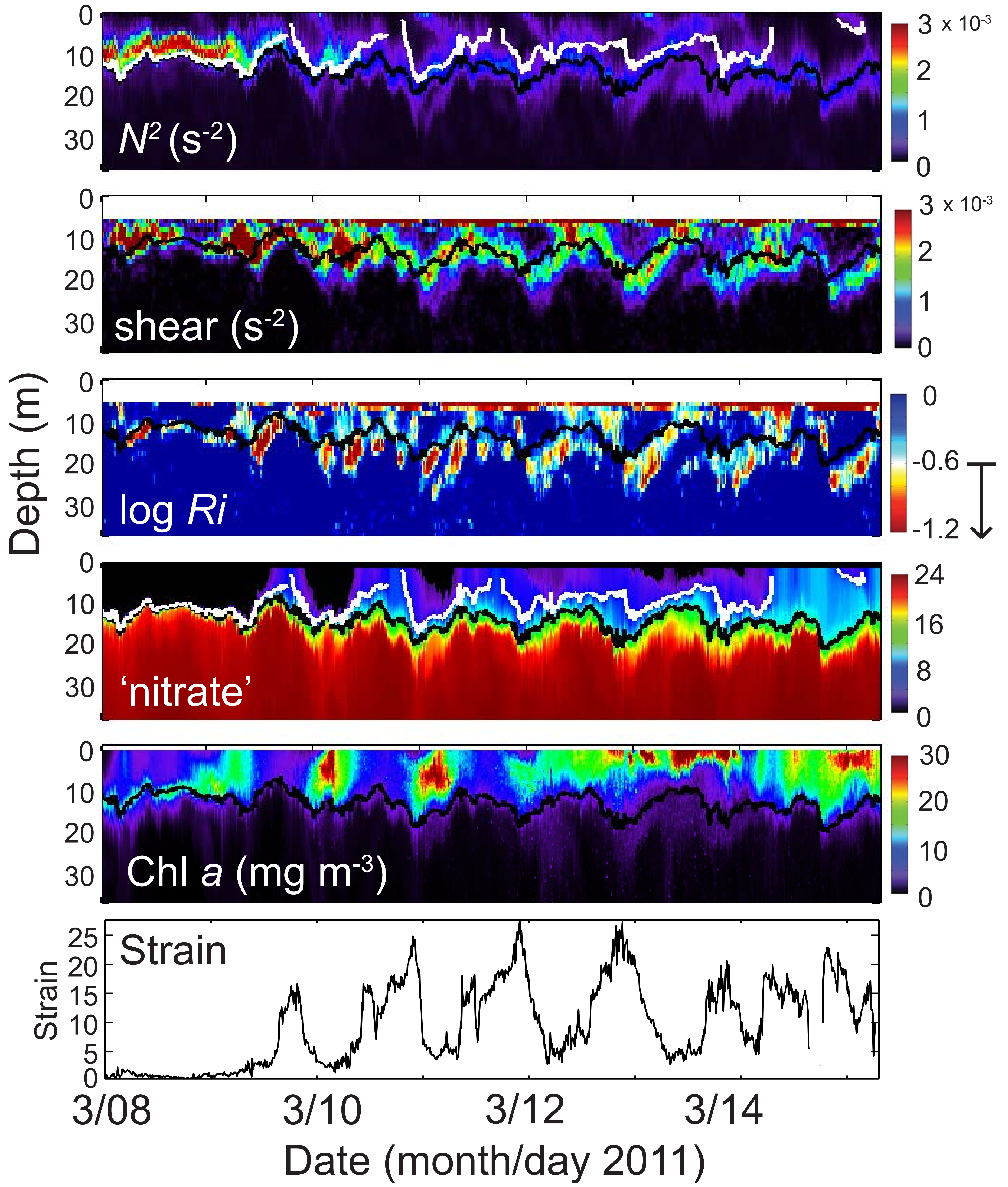
Wirewalker observations

Lucas et al. 2014 *DSRII, Pitcher et al. 2014 JGR*
See also Lucas et al. 2011, Limnol. Ocean.

Wirewalker and the Coastal Ocean

SCRIPPS INSTITUTION OF OCEANOGRAPHY





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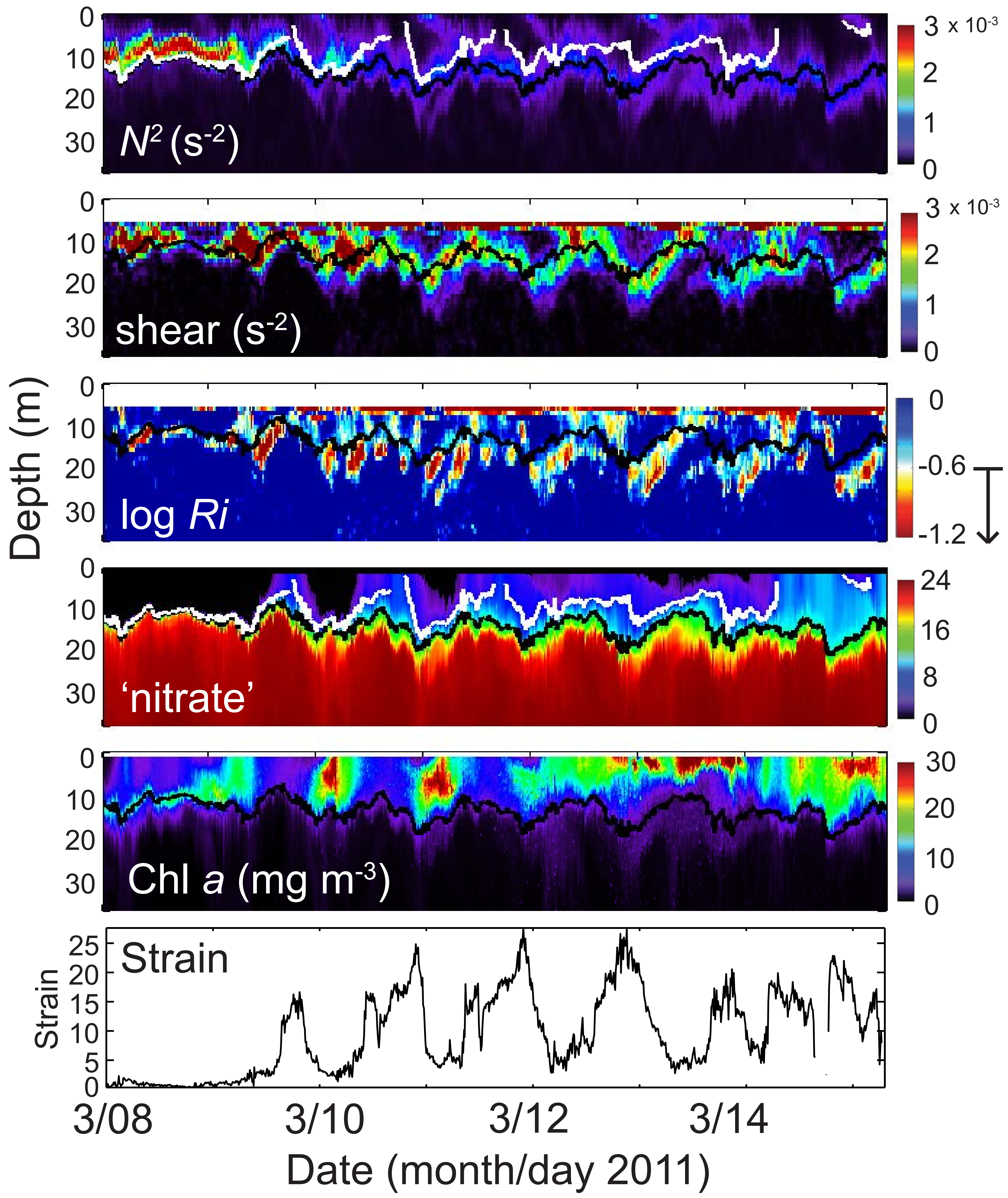
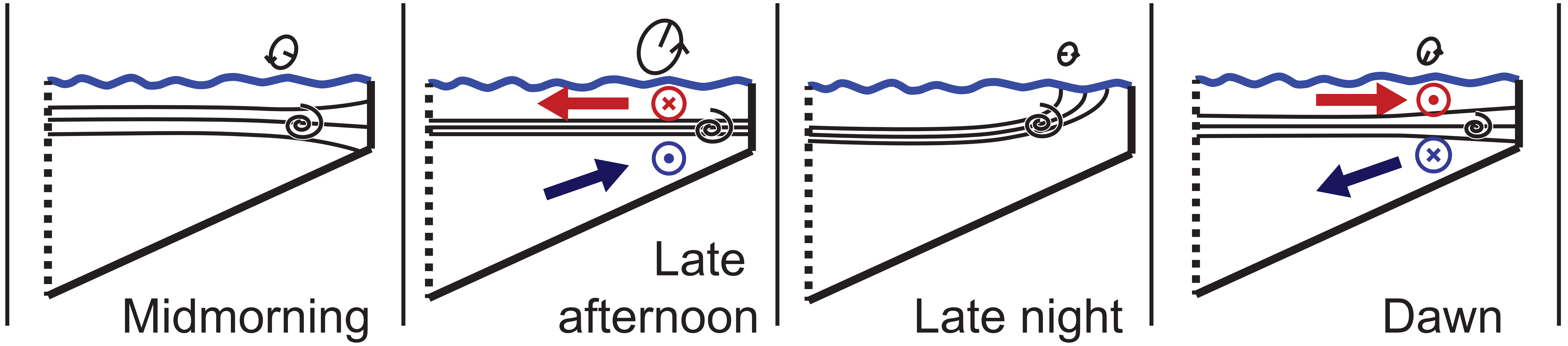
Wirewalker and the Coastal Ocean

SCRIPPS INSTITUTION OF OCEANOGRAPHY



Biological Response



Lucas et al. 2014 *DSRII*
Pitcher et al. 2014 JGR

Lucas et al. 2014 *DSRII, Pitcher et al. 2014 JGR*
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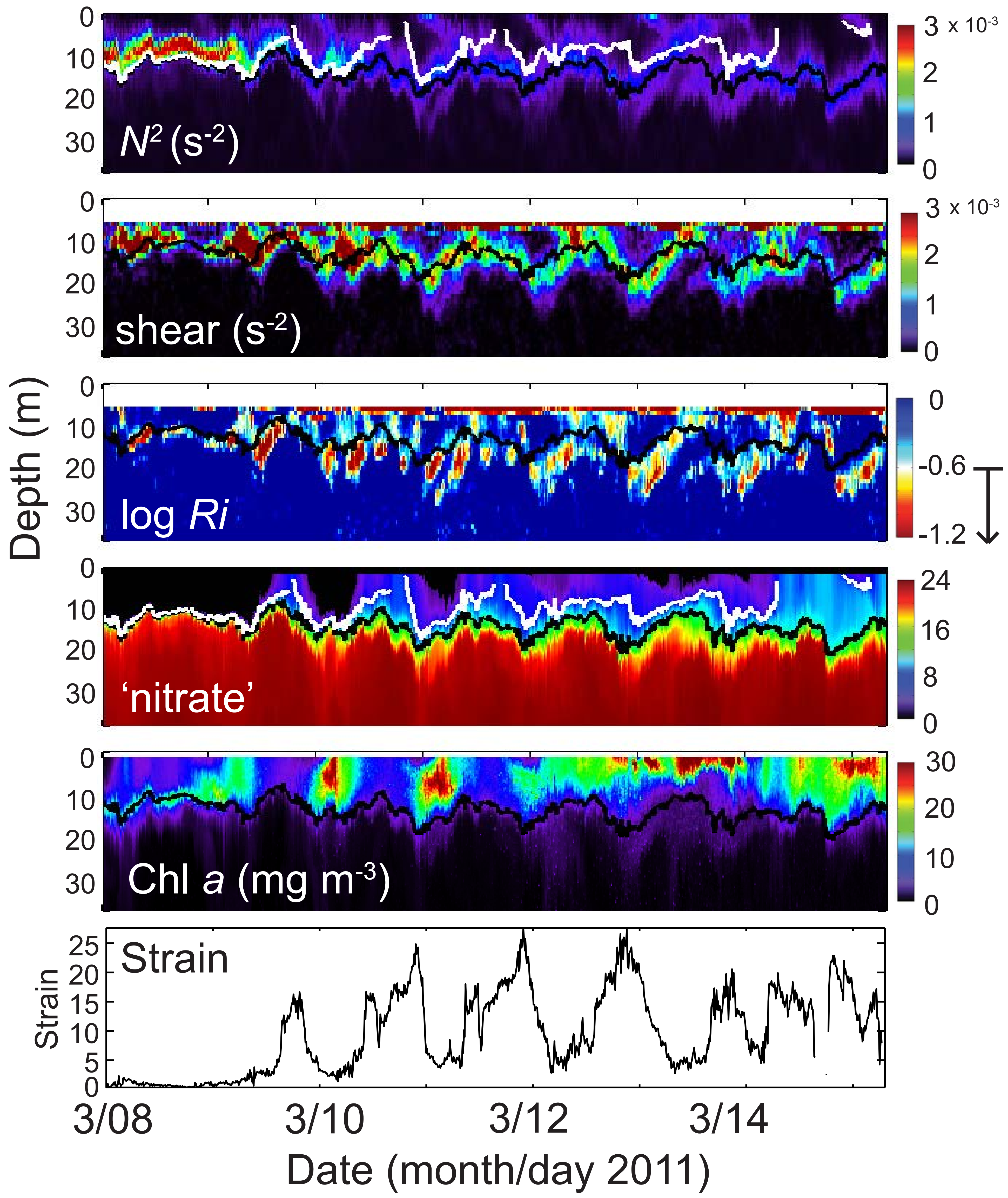
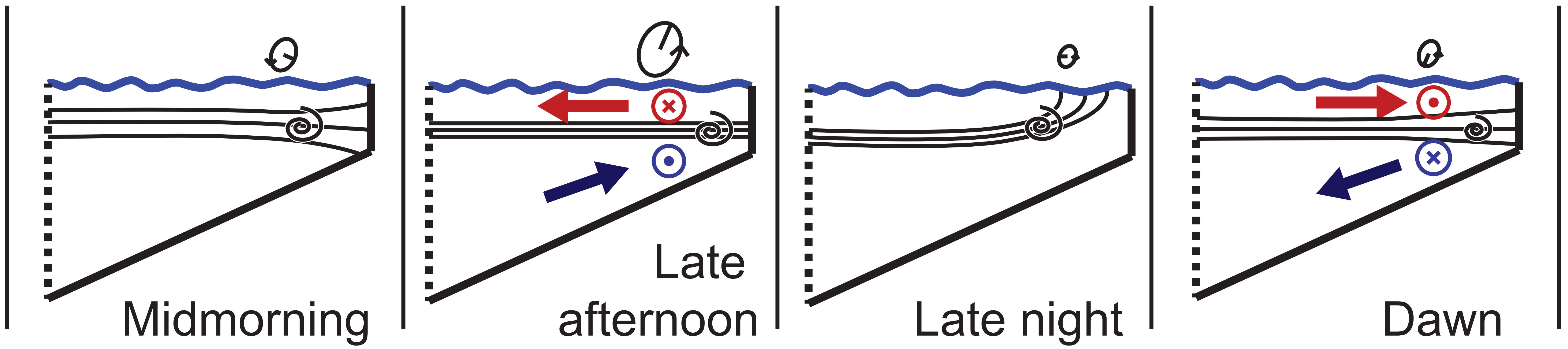
Wirewalker and the Coastal Ocean



Biological Response



Lucas et al. 2014 *DSRII*
Pitcher et al. 2014 JGR

Wirewalker and the Coastal Ocean

SCRIPPS INSTITUTION OF OCEANOGRAPHY

Southern Southern California Bight:

Stratified throughout the year.

Semidiurnal variability large relative to the sub-inertial.

Coastal ecosystems powered by the internal tide.

“Green tide” offshore of Scripps Institution of Oceanography

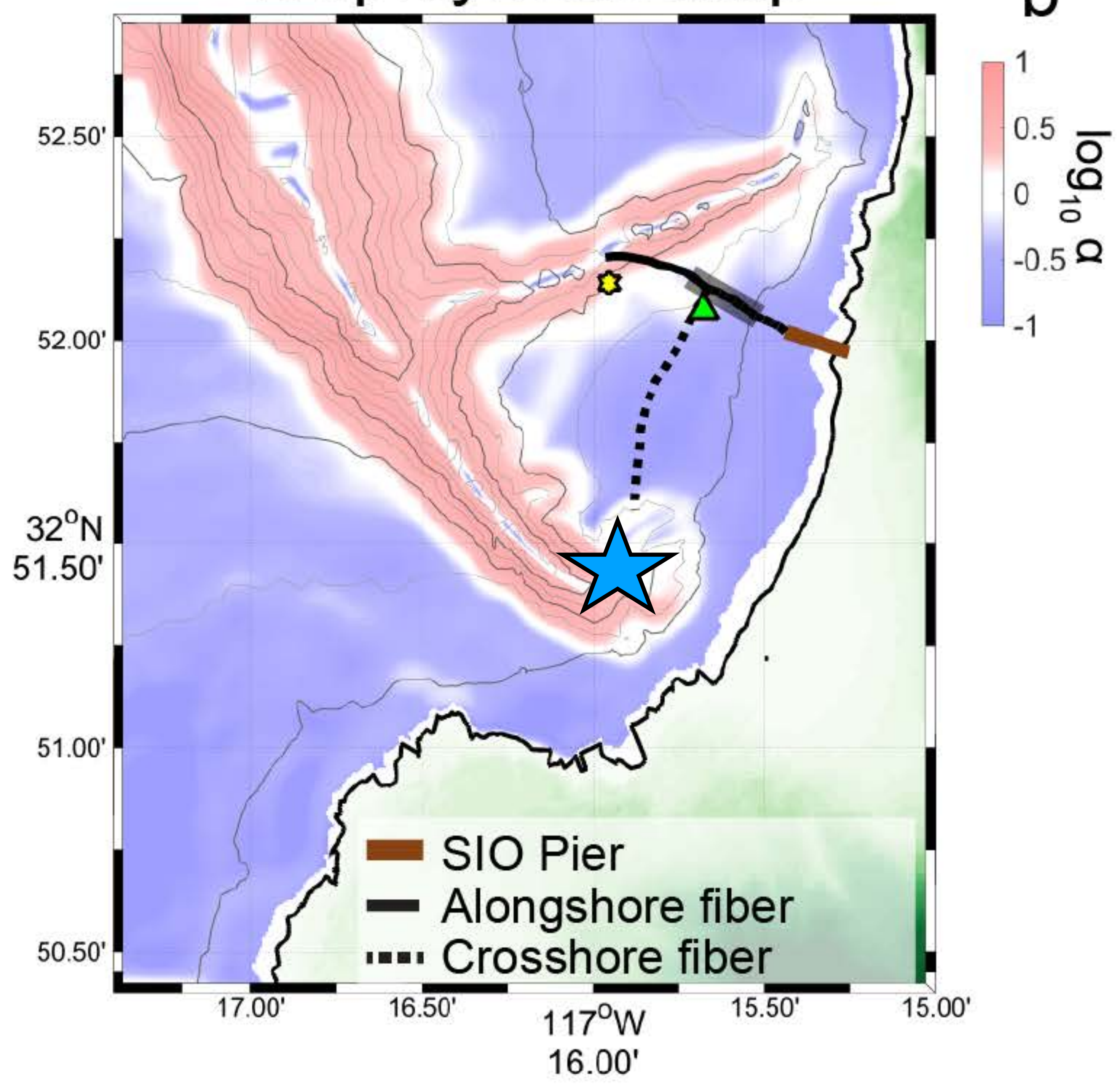
Photo: Eddy Kisfauldy

Alberty, M. S., Billheimer, S., Hamann, M. M., Ou, C. Y., Tamsitt, V., Lucas, A. J., and Alford, M. H. (2017), A reflecting, steepening, and breaking internal tide in a submarine canyon, *J. Geophys. Res. Oceans*, 122, 6872–6882, doi:10.1002/2016JC012583.

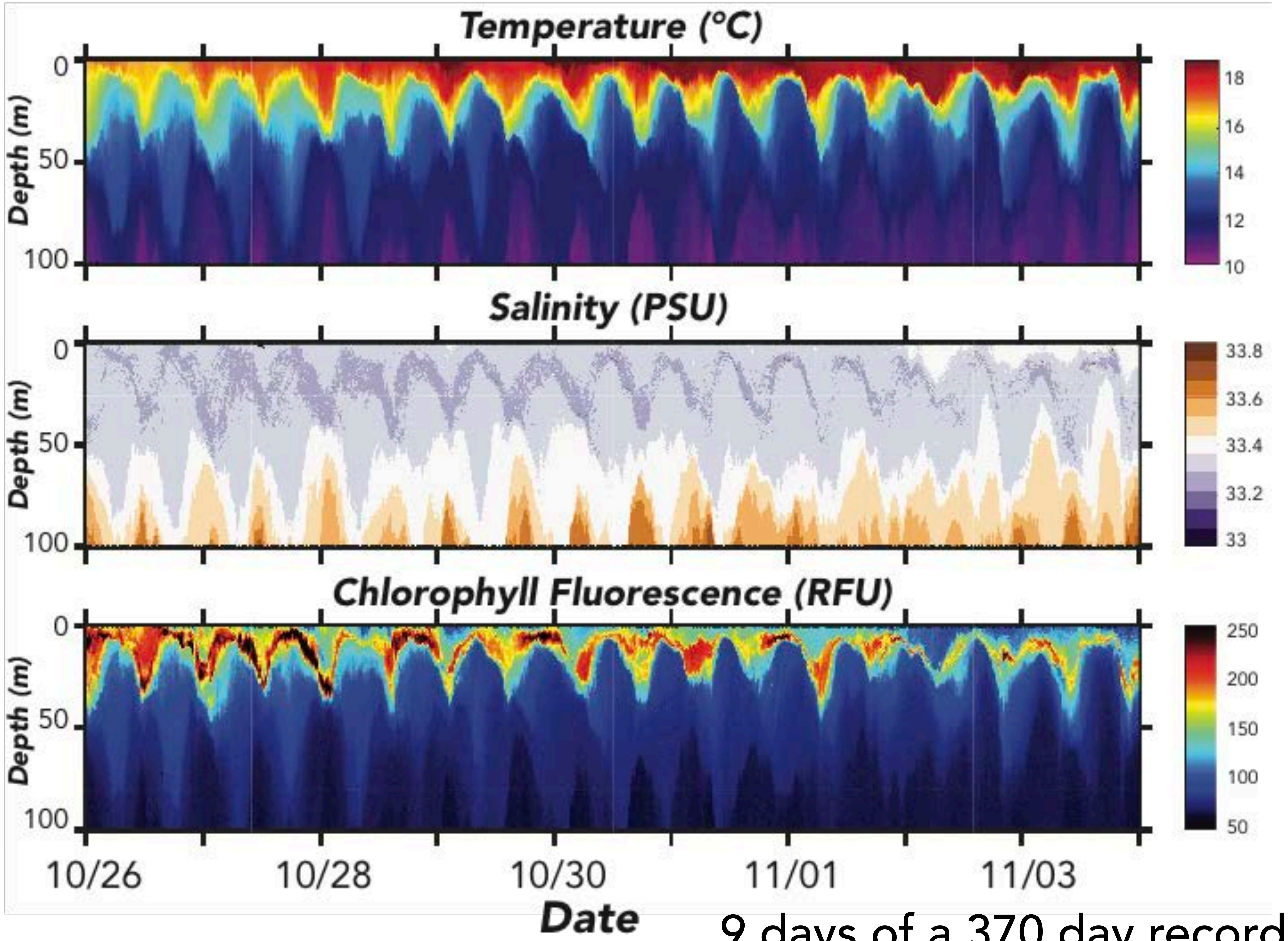
Wirewalker and the Coastal Ocean

SCRIPPS INSTITUTION OF OCEANOGRAPHY

Deployment map



Wirewalker data



La Jolla Canyon system drives a highly nonlinear transformation of the internal tide.

9 days of a 370 day record

Wirewalker and Coastal Ocean Water Quality

Fine-scale spatial and temporal effluent plume dynamics and coastal water quality assessment

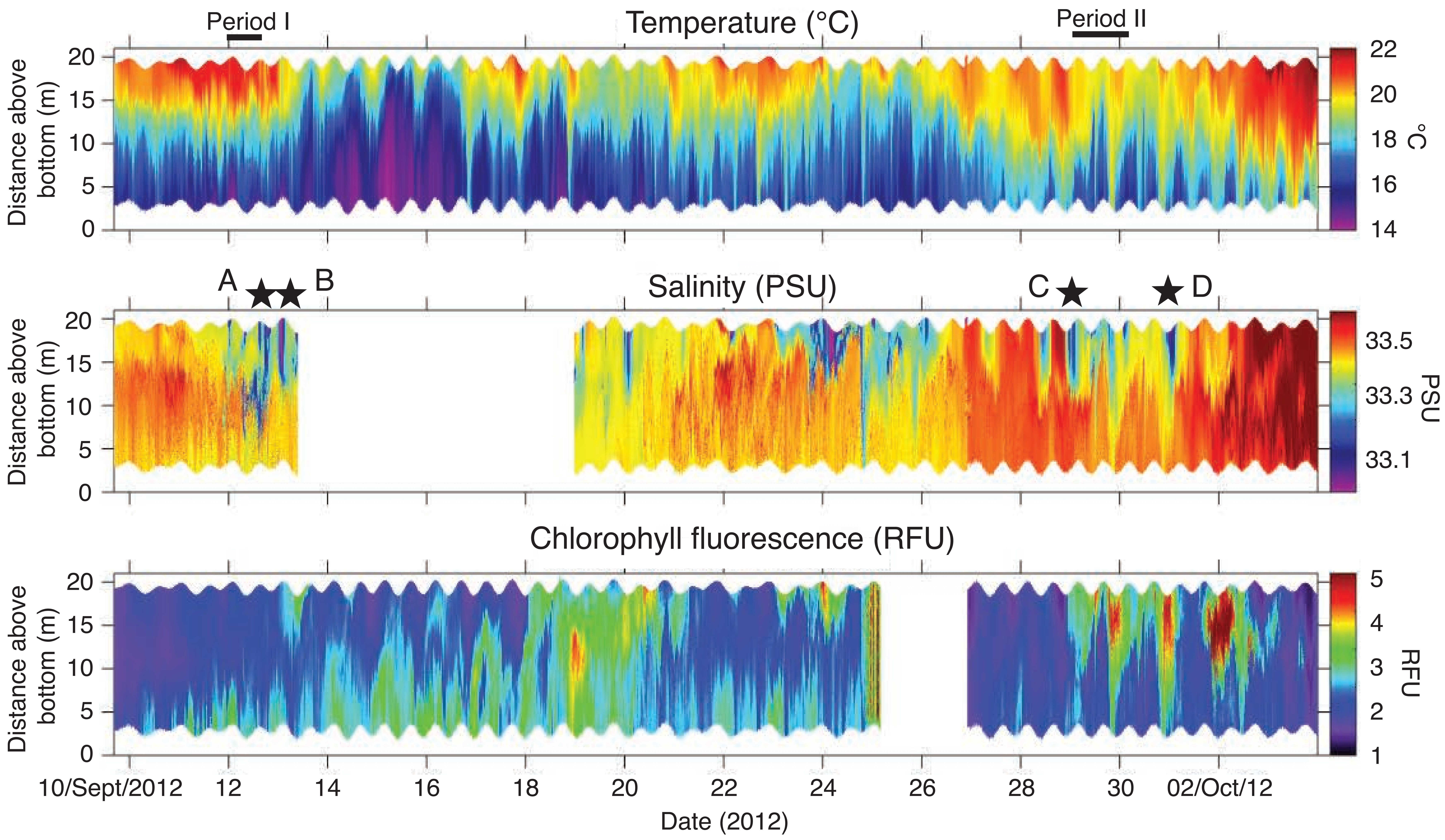
There are 21 Southern California Sanitation effluent treatment plants discharging ~1 BILLION gallons per day of treated effluent.

The fate and impact of pollutants in wastewater, and thus coastal water quality, are a function of both discharge dynamics and local oceanographic processes.

Wirewalkers were used to monitor wastewater diversion events at off Huntington Beach (2012, funded by NSF) and South Santa Monica Bay (2015, contract with City of LA*)

* Contract included delivery of real-time WW monitoring system

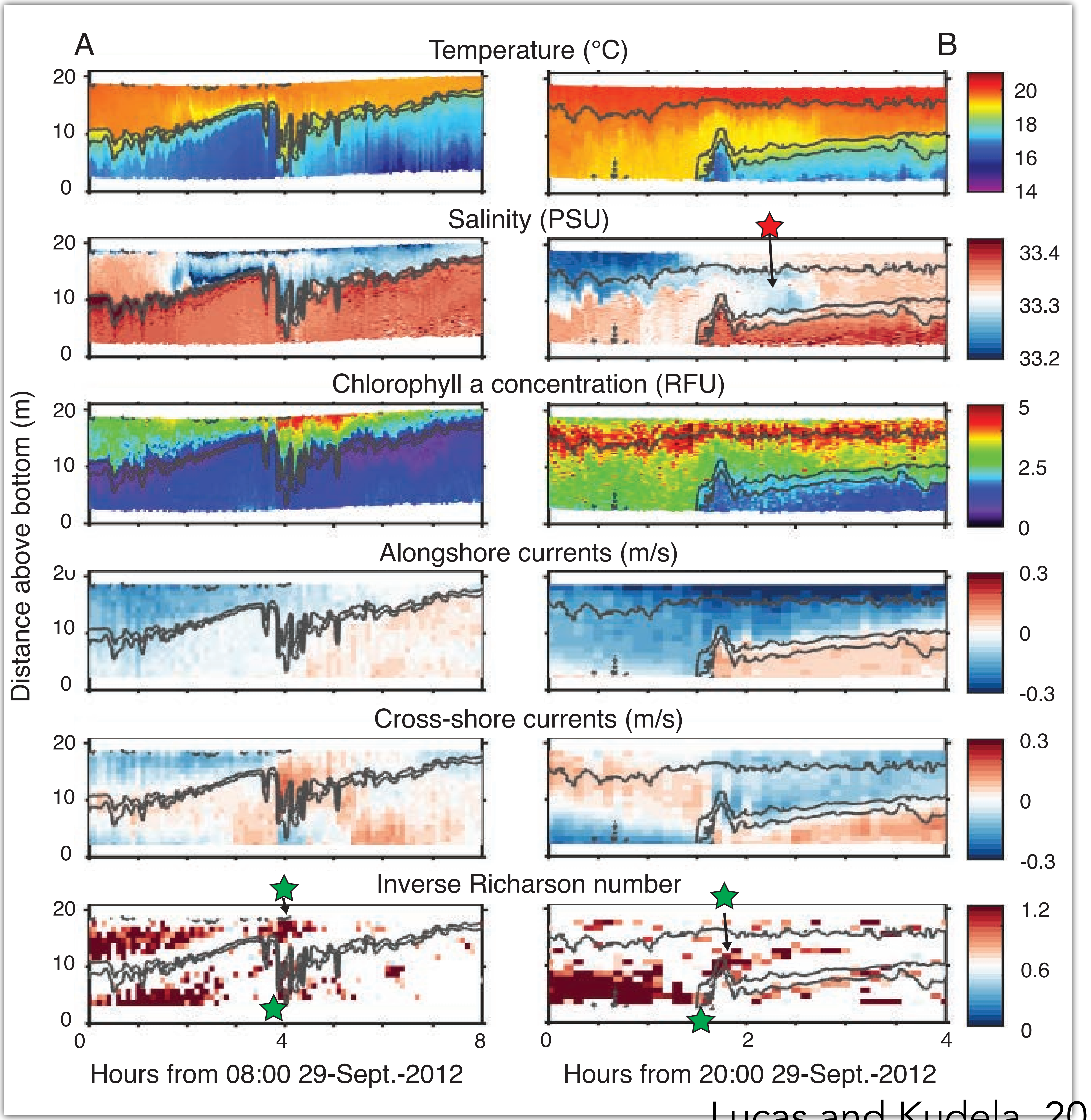
Wirewalker and Coastal Ocean Water Quality



Lucas and Kudela, 2015

Wirewalker and Coastal Ocean Water Quality

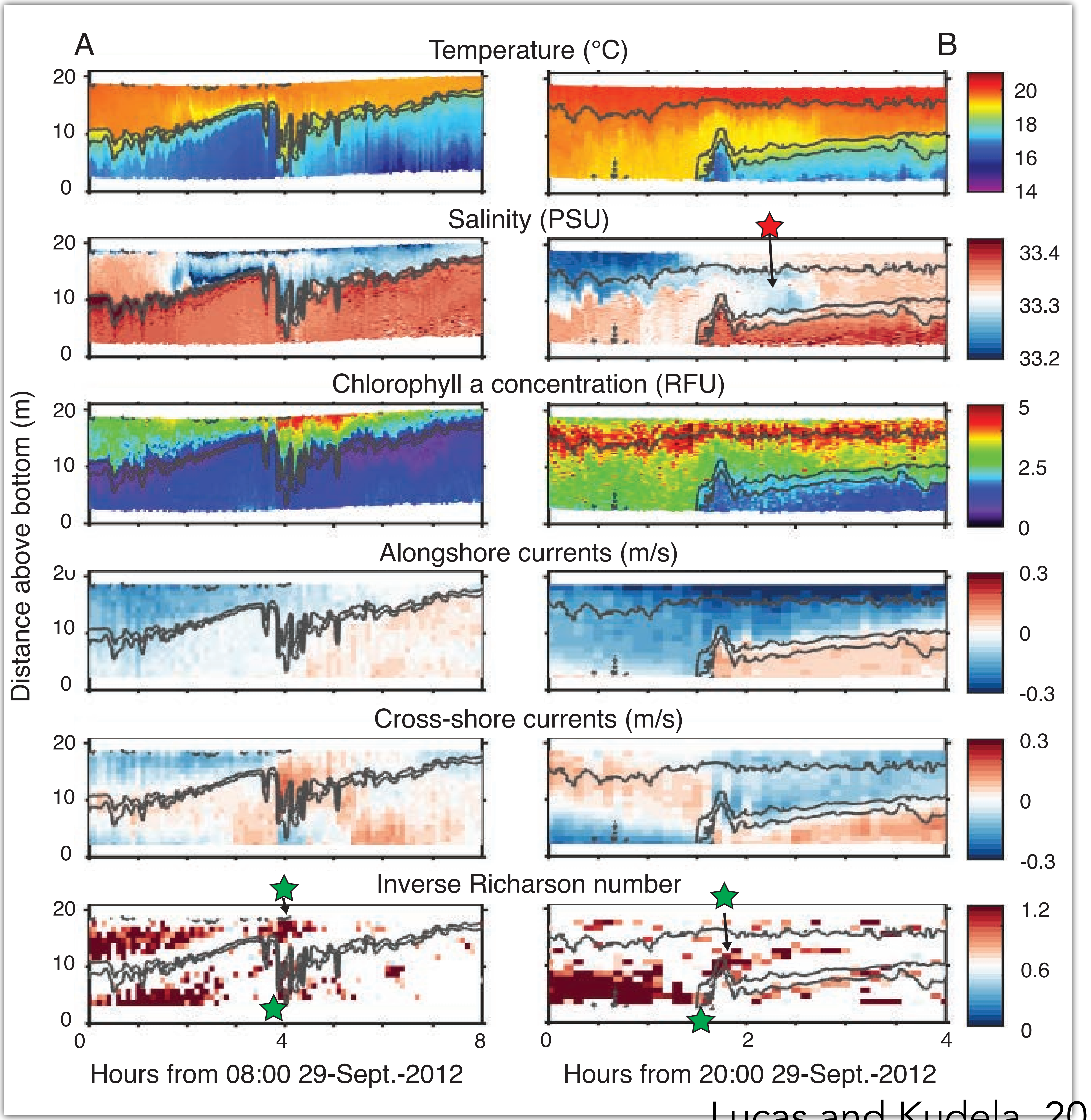
SCRIPPS INSTITUTION OF OCEANOGRAPHY



Lucas and Kudela, 2015

Complicated vertical structure of ocean currents, discharge plume, leads to complex and unpredictable dispersal.

Wirewalker and Coastal Ocean Water Quality



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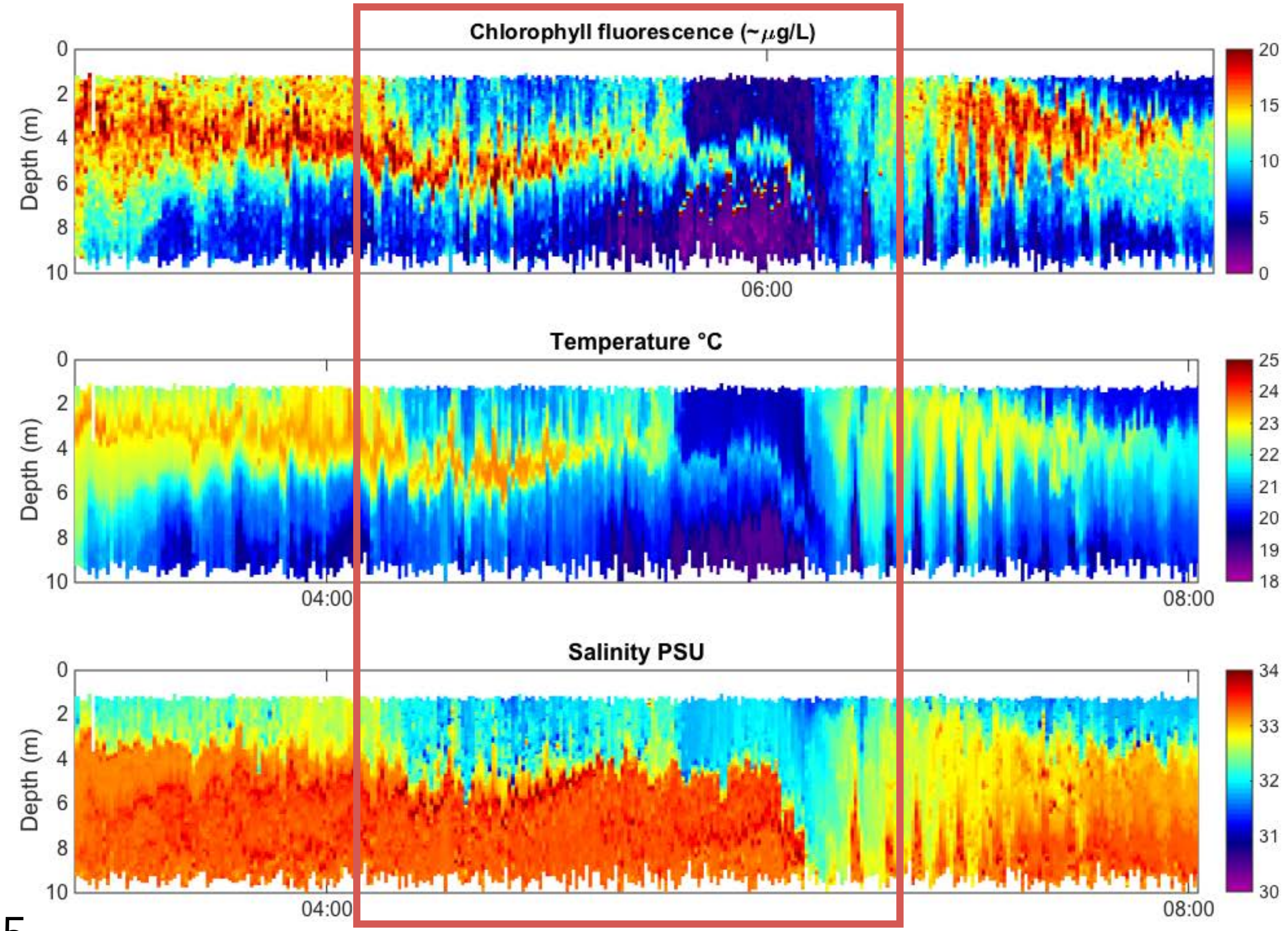
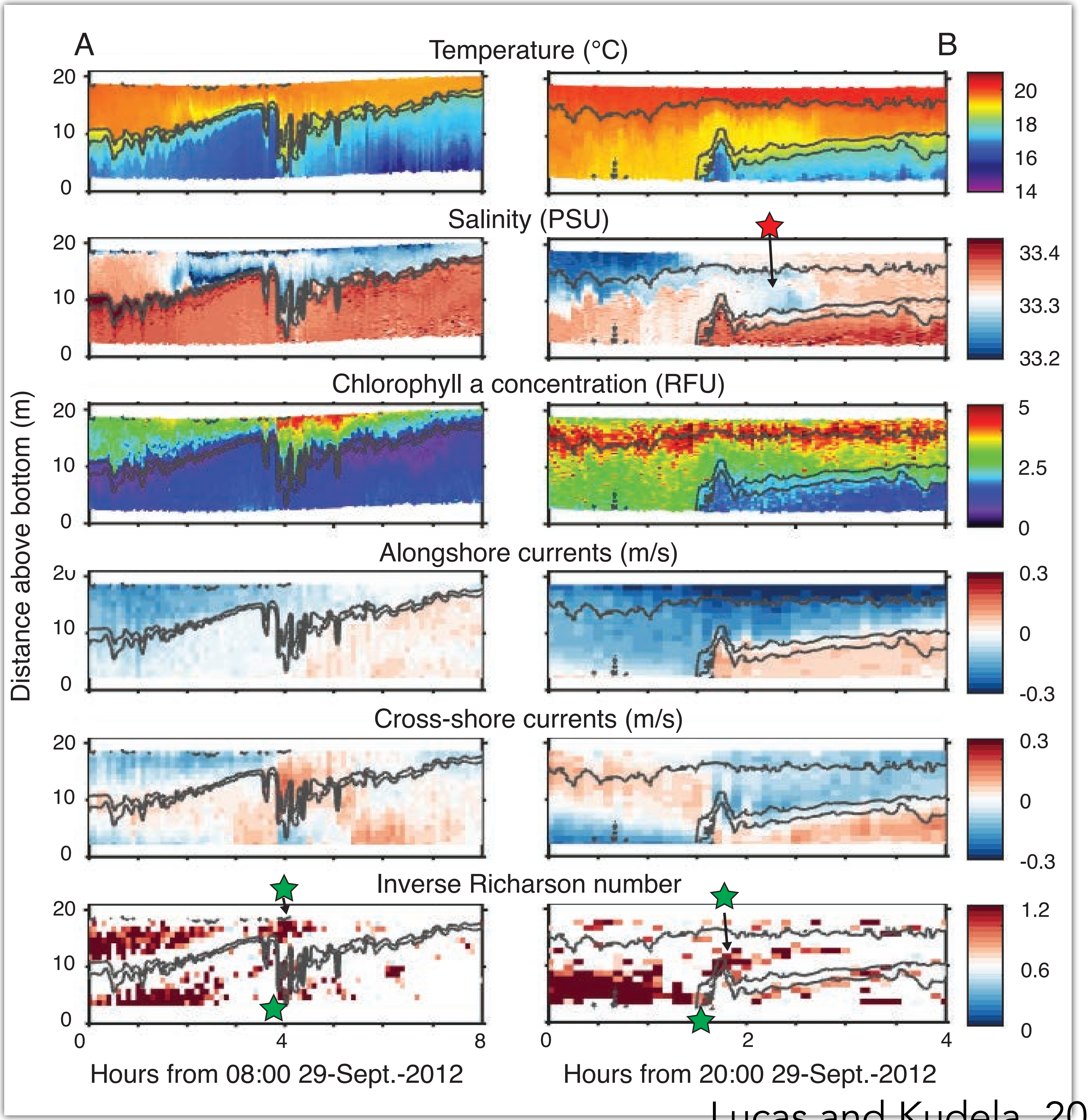


Wirewalker and Coastal Ocean Water Quality



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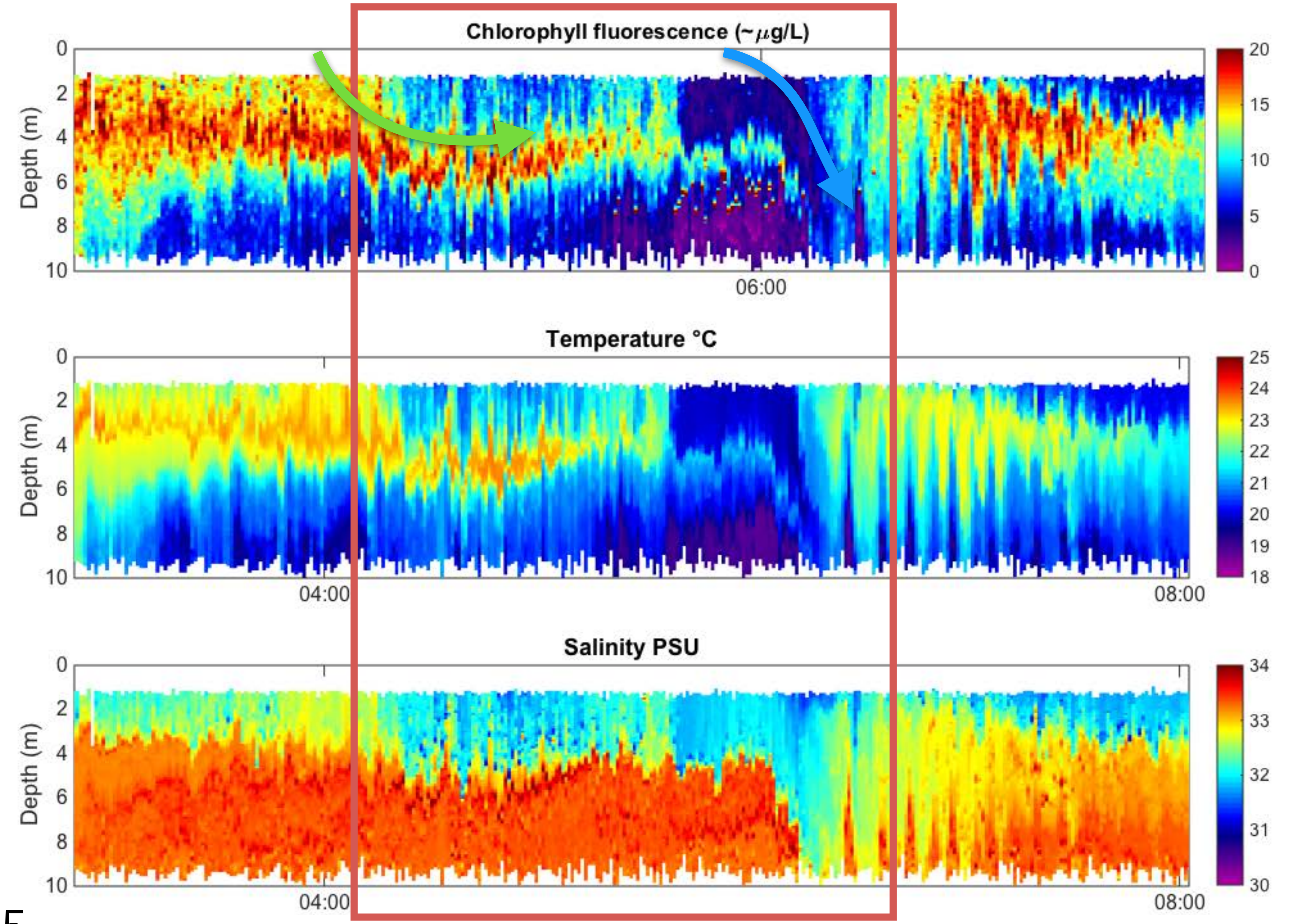


Lucas and Kudela, 2015

The Dynamics are in the Details: a decade of ocean exploration with the Wirewalker Profiler

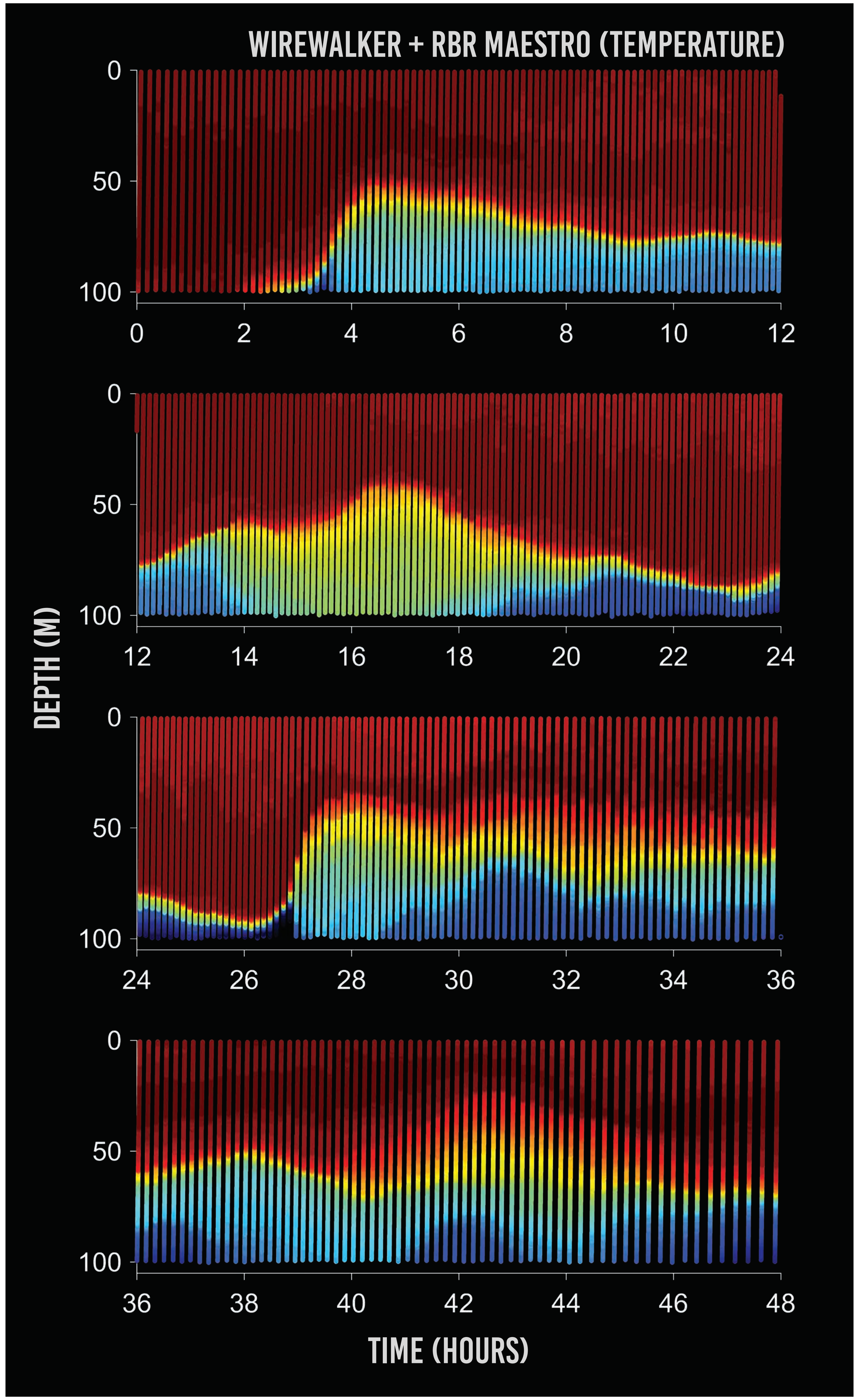
What's next?

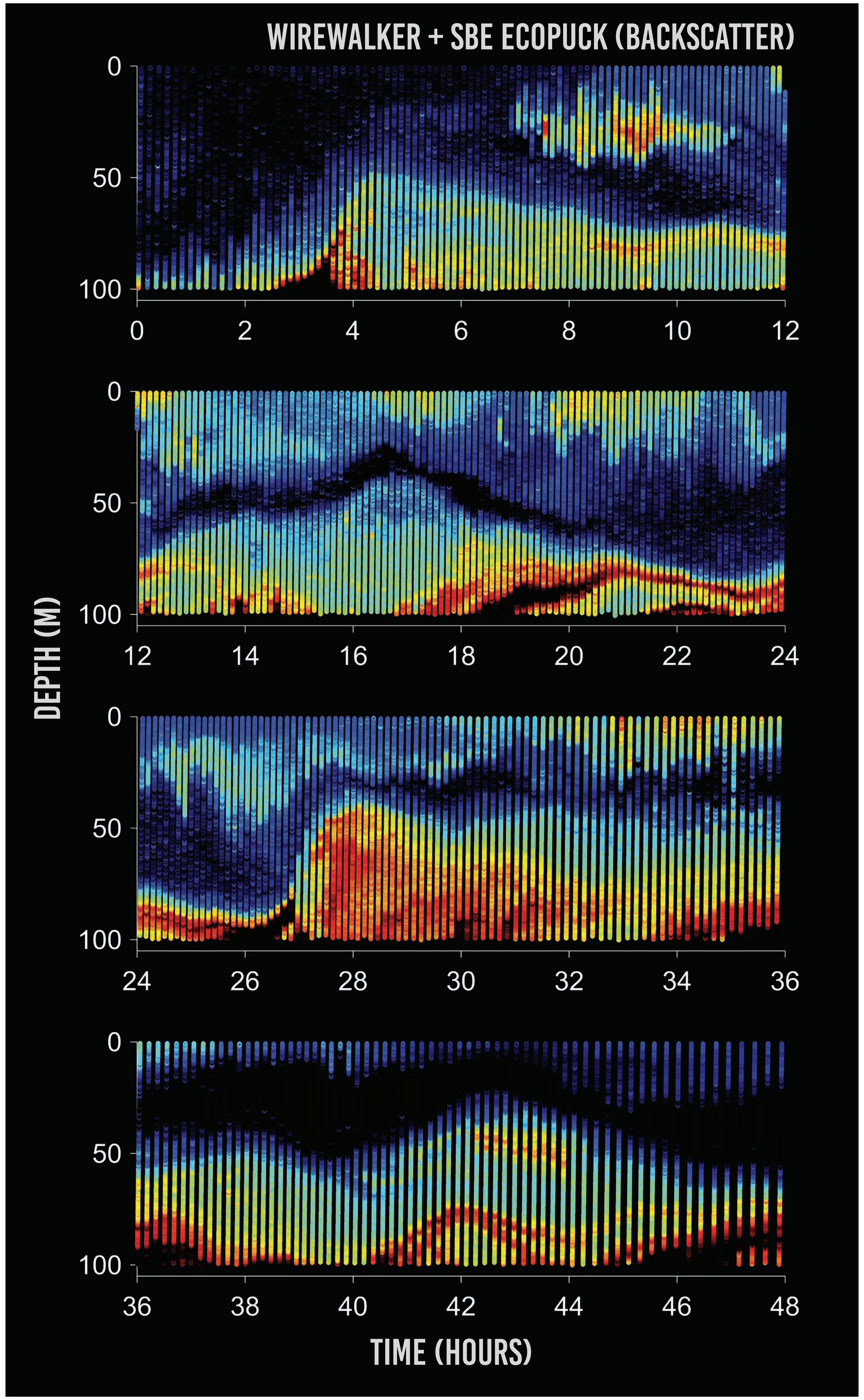
Full ocean depth moorings.

Onboard electrical power generation

Miniaturization

Smart sampling, long-term or one-way deployments





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Thank You

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